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Val Kucher

Gulf General Atomic
Incorporated

GAMD-8073
Addendum
Category A

TOIL
(A Two-material Version of the OIL Code)

Work done by:
W. E. Johnson

Report written by:
W. E. Johnson

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An addendum to GAMD-8073 by W. E. Johnson. This section is broken down into 5 parts as described below.

(A) TCLAM--the generator code for TOIL, presents sample problem, and instructions for usage.

(B) TOIL Equations--discusses the difference equations used in TOIL.

(C) Input for TOIL--describes the necessary data for using the TOIL code.

(D) Definition of Variables--defines the variables used in the TOIL code.

(E) TCLAM and TOIL--Fortran listings, consists of the actual Fortran listings with an abundant sprinkling of comments.

A. TCLAM CODE

General Description

TCLAM is a numerical code that provides the initial configuration and starting conditions for the TOIL code. This involves specifying the dimensions for each cell and the density, the two velocity components and the specific internal energy.

Below, Fig. 1, is a sketch of a typical two-dimensional grid. We display only a plane view, keeping in mind that each cell is really a solid of revolution, symmetric about the Z axis. In the discussion to follow, both X and R are referred to as the radial direction, and both Y and Z refer to the axial direction.

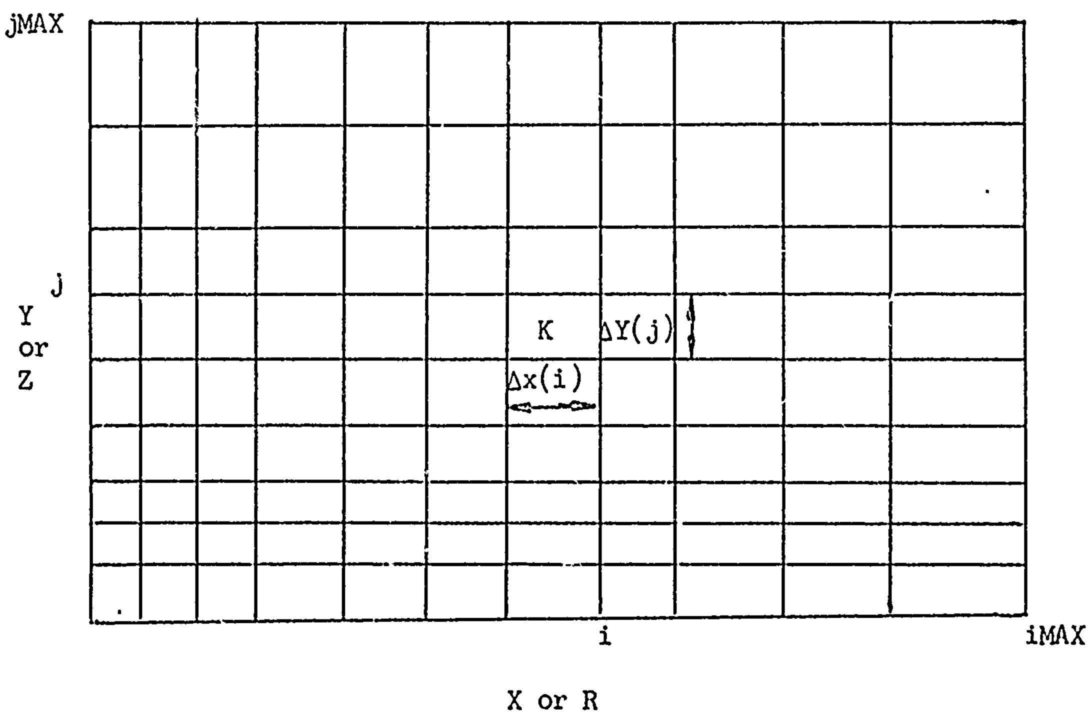


Fig. 1

i is the right boundary and j is the top boundary of cell K.

$$X(i) = \sum_{i=1}^{i} \Delta X(i)$$

$$Y(j) = \sum_{j=1}^{j} \Delta Y(j)$$

The area of cell (i, j) in the i direction = $2\pi\, X(i)\, \Delta Y(j)$.

The area of cell (i, j) in the j direction = $\pi(X^2_{(i)} - X^2_{(i-1)})$.

K is defined as (j-1) iMAX + i + 1, and is the index for all cell centered quantities.

First, we specify the total number of cells in the X direction (iMAX) and the total number of cells in the Y direction (jMAX). In addition, we specify the ΔX and ΔY for each cell. TCLAM then calculates the X(i) and Y(j) of each cell and the axial area (TAU(i) = $\pi(X^2_{(i)} - X^2_{(i-1)})$.

Next, specify the data for the various packages. This consists first of specifying the number of particles per cell for this package, and the type of material, and the origin of the radius vector for the density, energy and velocity functions. We also specify one of the 6 possible fits for the density, energy and velocity functions.

Next, specify the type of geometry (the configuration), of which there are four possible: circle, ellipse, rectangle and triangle. Thus, the configuration can be broken up into combinations of the four possible geometries (note, these geometries are really solids of revolution for the cylindrical geometry). The data for these geometries are stored in the array (TAB). A counter (IWS) is calculated from the initial data. This counter is stored in the first word of the TAB block for each package. Its values are as follows:

iWS = 1	delete this triangle
iWS = 2	generate this triangle
iWS = 3	delete this rectangle
iWS = 4	generate this rectangle
iWS = 5	delete this circle or ellipse
iWS = 6	generate this circle or ellipse

The next 6 words of this TAB block contain the coordinates of the desired geometry. The next card contains the data for the density fit and we store this data in the array (TABR). Next, read in the data for the internal energy and store it in the TABI array. The last data card of each package contains the input for the velocity fit, and this data is stored in the TABUV array.

We then compute the boundaries of the specified geometry, and the minimum and maximum i and j values for this geometry.

Next we subdivide all the cells in this package into N (the number of particles per cell) equal area cells. The particles are placed at the center of each sub-cell, where the volume of the sub-cell = $2\pi(XL)(DY/WS)(DX/WS)$ where $WS = (N)^{\frac{1}{2}}$ and XL = the X value of the center of the sub-cell. Some of the particles (N) may not be generated, however, for if the boundary of the geometry passes through the cell, those particles that fall outside of the boundary are deleted.

We assign a density, two velocity components and a specific internal energy to each package. These may be any function of XL, YL or R where XL = X coordinate of the particle N, YL = Y coordinate of particle N, and $R = (TTX^2 + TTY^2)^{\frac{1}{2}}$ where TTX = XL - XC and TTY = YL - YC; XC and YC are the coordinates of the origin of the radius vector R, they are inputed on the first card of each package. The mass of each particle is the density times the volume of the subdivision cell of cell K.

After processing all N particles for cell K, we calculate the total mass of cell K as

$$\sum_{n=1}^{N} m_n \quad ,$$

the axial momenta as $\sum_{n=1}^{N} V_n m_n$, the radial momenta as $\sum_{n=1}^{N} U_n m_n$ and the internal energy as $\sum_{n=1}^{N} I_n m_n$. In addition, the total energy and mass of all cells are summed up for the entire package.

The normal units for TCLAM are as follows:

m = particle mass in grams

AMX = mass of cell K in grams for the (x) material

AMD = mass of cell K in grams for the (.) material

U = radial velocity in cm/shake (1 shake = 10^{-8} sec)

V = axial velocity in cm/shake

AiX = specific internal energy in jerks/gram for (x) material (1 jerk = 10^{16} ergs)

AiD = specific internal energy in jerks/gram for (.) material.

After all cells in this package have been processed, we read in another package and proceed as before.

After all packages have been processed, we then convert the axial and radial momenta of each cell K to an axial and radial velocity component. The internal energy of cell K is converted to specific internal energy.

The output from TCLAM (a binary tape that can be read by the TOIL code) consists of the cell dimensions, total number of cells in both directions, the mass and two velocity components, the specific internal energy of each cell K and other information required for the TOIL program.

The Fortran symbols and units are listed below:

AMD = total mass in cell K (grams) for the (.) material

AMX = total mass in cell K (grams) for the (x) material

AiX = specific internal energy in cell K (jerks/gram) for (x) material

AiD = specific internal energy in cell K (jerks/gram) for (.) material

U = radial velocity of cell K (cm/shake)

V = axial velocity of cell K (cm/shake)

X = dimension in cm of the right boundary of the cell

Y = dimension in cm of the top boundary of the cell

iMAX = total number of cells in the X direction

jMAX = total number of cells in the Y direction

kMAX = (iMAX)(jMAX) + 1.

For clarification, in generating data for the TOIL code, the creation of particles is only a computational technique to give the proper density, velocity and internal energy as specified. These particles are not saved after they have been summed for the cell in question.

Below we list a complete description of the required input and format for the TCLAM code.

INPUT DESCRIPTION FOR TCLAM

An asterisk before the work signifies that the data is floating point; otherwise it is fixed point data.

Card No.		Column No.	Description
1		2 - 72	Header card, any BCD information.
2	*	1 - 10	Contain the problem number.
	*	11 - 20	iMAX, the number of cells in the X-direction (maximum of 100).
	*	21 - 30	jMAX, the number of cells in the Y-direction (maximum of 100). (iMAX)(jMAX) ≤ 4499
	*	31 - 40	= 0.
	*	41 - 50	2.
	*	51 - 60	Blank.
	*	61 - 70	Blank.
		71 - 72	N7 = binary tape number.
3	(2 number 3 cards is the minimum)		
		1	A (1) indicates that this is the last DX or DY card to be read in. A (0) indicates that there will be more DX or DY cards.
		2	A (0) indicates DX data. A (1) indicates DY data.

Card No.		Column No.	Description
		3 - 4	Indicates the number of zones that will have the same DX or DY values that appear in Columns 11 - 20.
		5 - 6	Indicates the number of zones that will have the same DX or DY values that appear in Columns 21 - 30.
		7 - 8	Indicates the number of zones that will have the same DX or DY values that appear in Columns 31 - 40.
		9 - 10	Indicates the number of zones that will have the same DX or DY values that appear in Columns 41 - 50.
	*	11 - 20	The value of DX or DY.
	*	21 - 30	The value of DX or DY.
	*	31 - 40	The value of DX or DY.
	*	41 - 50	The value of DX or DY.
4	*	1 - 10	Blank.
	*	11 - 20	Blank.
	*	21 - 30	80.
	*	31 - 40	Blank.

Now we begin leading the data to generate a package. The maximum number of geomtries that may be generated is 72; to increase the maximum requires the changing of dimensions.

	Column No.	Description
1	1	Load a 1 here.
	2	A (1) implies that X material will be generated in this package. A (0) implies that dot material will be generated.
	5 - 7	(N^2), the number of particles per cell to be generated, where $1 \leq N \leq 20$. Note, the unit digit in Column 7 the 10 digit in Column 6, the 100 digit in Column 5.

Card No.		Column No.	Description
	*	11 - 20	YC = Y coordinate for the origin of the radius vector used in the density, energy and velocity fits.
	*	21 - 30	XC = X coordinate for the origin of the radius vector used in the density, energy and velocity fits.
	*	31 - 40	A number (1 through 6) that specifies the fit number or subroutine to use for this package to calculate the density, velocities and specific internal energy of the N particles.
	*	41 - 70	Blank.

Following the first card of each package are five other types of cards.

1. Generate geometry (see options below).
2. Delete geometry (see options below).
3. A density card (only one per package).
4. An energy card (only one per package).
5. A velocity card (only one per package).

For cards (1) and (2), TCLAM has the following geometric options for generating or deleting:

1. A rectangle			A (4) in Column 1. Columns 2 - 6 are blank. A (1) in Column 7 means to generate this rectangle. A (0) in Column 7 means to delete this rectangle.
	*	11 - 20	X1 = the left X coordinate of this rectangle.
	*	21 - 30	X2 = the right X coordinate of this rectangle.
	*	31 - 40	Y1 = the lower Y coordinate of this rectangle.
	*	41 - 50	Y2 = the upper Y coordinate of this rectangle.

Card No.	Column No.	Description
2. A triangle		A (6) in Column 1, Columns 2 - 6 are blank. A (1) in Column 7 means to generate this triangle. A (0) in Column 7 means to delete this triangle.
	* 11 - 20	X1
	* 21 - 30	Y1
	* 31 - 40	X2
	* 41 - 50	Y2
	* 51 - 60	X3
	* 61 - 70	Y3
		NOTE: Vertices (1-3) can be in any order.
3. An ellipse or circle		A (41) in Columns (1-2), Columns 3 - 6 are blank. A (1) in Column 7 means to generate this ellipse or circle. A (0) in Column 7 means to delete this ellipse or circle.
	* 11 - 20	The semi-axis in the X-direction if an ellipse or the radius if for a circle.
	* 21 - 30	The semi-axis in the Y-direction if an ellipse or zero for a circle.
	* 31 - 40	The X-coordinate of the center of ellipse or circle.
	* 41 - 50	The Y-coordinate of the center of ellipse or circle.

Following the geometry cards are the following data cards that refer to all cells within this package:

Density card - a 51 in Columns (1-2).
Energy card - a 52 in Columns (1-2).
Velocity card - a 53 in Columns (1-2).

NOTE: If in this package, the density or internal energy or velocities will remain the same as t e previous package, then a 51, 52, or 53 card is not requi .

Card No.	Column No.	Description
*	11 - 20	Contains the values to be used in the analytical expressions for the density, energy, and velocities.
*	21 - 30	
*	31 - 40	
*	41 - 50	
*	51 - 60	
*	61 - 70	

This data is loaded into the following Fortran arrays:

TABR (1-6) The 6 constants available for the density fits.

TABI (1-6) The 6 constants available for the internal energy fits.

TABUV (1-6) The 6 constants available for the two velocity components.

Finally, the last card will have a 2 in Column 1, this signifies the completion of loading all input cards into the TCLAM code.

SPECIAL SUBROUTINES

There are six subroutines labeled FIT 1 - FIT 6, used to compute the density, internal energy and velocities.

The standard input to these subroutines is as follows:

TY = Y coordinate of particle N.

TX = X coordinate of particle N.

The modified coordinates TTY and TTX are computed as follows:

TTY = Y coordinate = TY - YC (relative to YC)

TTX = X coordinate = TX - XC (relative to XC)

Note: YC and XC are the Y and X coordinate for the origin of the radius vector used in the density, energy and velocity fits.

The standard output from these subroutines is as follows:

WSR - contains the density of particle N.

WSI - contains the specific internal energy of particle N.

WSU - contains the radial velocity component for particle N.

WSV - contains the axial velocity component for particle N.

1. FIT 1

$$\begin{bmatrix} R = (X^2 + Y^2)^{\frac{1}{2}} \\ WS = (TTX^2 + TTY^2)^{\frac{1}{2}} \end{bmatrix}$$

$$\begin{bmatrix} \rho = A + B\ (Y - C) \\ WSR = TABR(1) + TABR(2)\ [TTY - TABR(3)] \end{bmatrix}$$

$$\begin{bmatrix} I = A + B\ (Y - C) \\ WSI = TABi(1) + TABi(2)\ [TTY - TABi(3)] \end{bmatrix}$$

$$\begin{bmatrix} U = 0. \\ WSU = 0. \end{bmatrix}$$

$$\begin{bmatrix} V = A + B\ (Y - C) \\ WSV = TABUV(1) + TABUV(2)\ [TTY - TABUV(3)] \end{bmatrix}$$

2. FIT 2

$$\begin{bmatrix} R = (X^2 + Y^2)^{\frac{1}{2}} \\ WS = (TTX^2 + TTY^2)^{\frac{1}{2}} \end{bmatrix}$$

$$\begin{bmatrix} \rho = \left(\frac{X-A}{B}\right)^2 + \left(\frac{Y-C}{D}\right)^2 \\ WSR = \left(\frac{TTX - TABR(1)}{TABR(2)}\right)^2 + \left(\frac{TTY - TABR(3)}{TABR(4)}\right)^2 \end{bmatrix}$$

$$\begin{bmatrix} I = A + BX + CX^2 + DY + EY^2 \\ WSI = TABi(1) + TABi(2)(TTX) + TABi(3)(TTX)^2 \\ + TABi(4)(TTY) + TABi(5)(TTY)^2 \end{bmatrix}$$

$$\begin{bmatrix} U = C + DY \\ WSU = TABUV(3) + TABUV(4) * TTY \end{bmatrix}$$

$$\begin{bmatrix} V = A + BY \\ WSV = TABUV(1) + TABUV(2) * TTY \end{bmatrix}$$

3. FIT 3

$$\left[\begin{array}{c} R = (X^2 + Y^2)^{\frac{1}{2}} \\ WS = (TTX^2 + TTY^2)^{\frac{1}{2}} \end{array}\right]$$

$$\left[\begin{array}{c} \rho = A + B\ (Y - C) \\ WSR = TABR(1) + TABR(2)\ [TTY - TABR(3)] \end{array}\right]$$

$$\left[\begin{array}{c} I = A \sin \left(\frac{2\pi Y}{B}\right) \\ WSI = TABi(1) \sin \left(\frac{TTY}{TABi(2)}\ 2\pi\right) \end{array}\right]$$

$$\left[\begin{array}{c} U = 0. \\ WSU = 0. \end{array}\right]$$

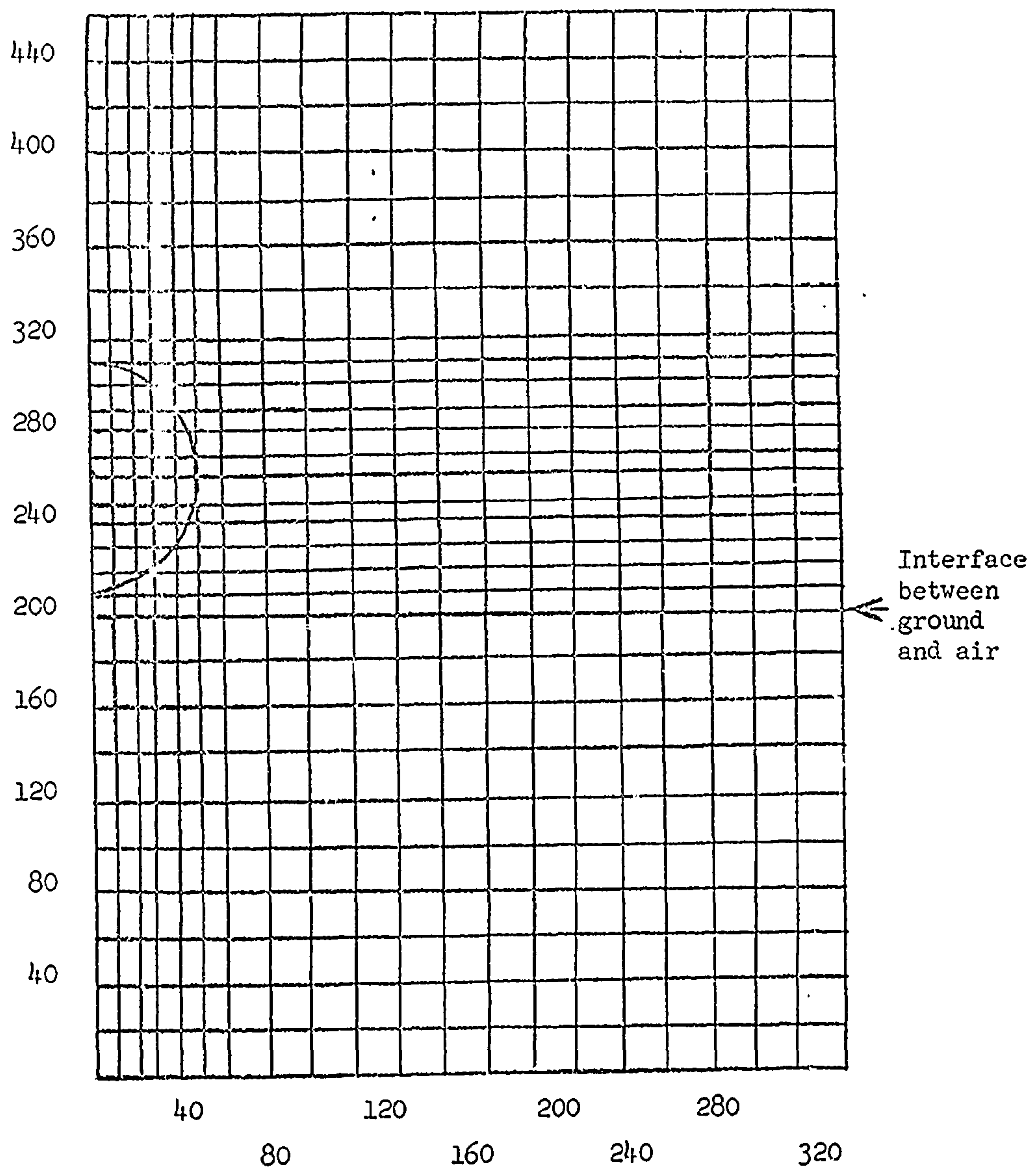
$$\left[\begin{array}{c} V = A + B\ (Y - C) \\ WSV = TABUV(1) + TABUV(2)\ [TTY - TABUV(3)] \end{array}\right]$$

4. FIT 4 - FIT 6

These are dummy subroutines. Any analytical expression for density, energy and velocity may be programmed into these remaining subroutines by following the prescribed formats.

EXAMPLE OF A CONFIGURATION

Example of the input required to use the TCLAM code to generate starting conditions for TOIL code.



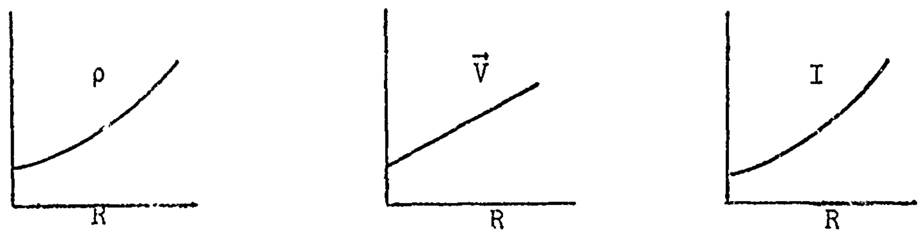
iMAX = 20

jMAX = 29

A hot source 60 cm from the ground

We will assume the source to be of the same material as the ground, and that the air be the other material.

The distribution of the hot source might be as follows:



6 ΔX's of 10 cm
14 ΔX's of 20 cm

10 ΔY's of 20 cm
12 ΔY's of 10 cm
7 ΔY's of 20 cm

Package (1) generates a rectangle (the ground) from $X_1 = 0$ to $X_2 = 340$ cm and from $Y_1 = 0$ to $Y_2 = 200$ cm

1 particle/cell and YC = 0 = XC (X material)

$$\left.\begin{array}{l} \rho = 1.97 \\ I = 0 \\ U = V = 0 \end{array}\right\} \text{Use FIT 1}$$

Package (2) generates a circle of radius 50 cm at X = 0 and Y = 260 cm. Generate 16 particles/cell and YC = 260 cm and XC = 0 (X material). The analytical expressions for the ρ, $\vec{V}$ and I are as follows:

$$\rho = A + BR + CR^2$$

$$I = G + HR + KR^2$$

$$\vec{V} = E + FR \quad .$$

To achieve the radial distribution for the 2 velocity components, we will program a new FIT subroutine, say FIT 4:

$$WS = (TTX^2 + TTY^2)^{\frac{1}{2}} \equiv R$$

$$WSR = TABR(1) + TABR(2)\ WS + TABR(3)\ WS^2 \equiv A + BR + CR^2 = \rho \text{ (density)}$$

$$WSi = TABi(1) + TABi(2)\ WS + TABi(3)\ WS^2 = G + HR + KR^2 = I \text{ (energy)}$$

$$WSA = TABUV(1) = TABUV(2)\ WS \equiv E + FR$$

$$WSU = \frac{TTX}{WS}\,[WSA] \equiv \frac{X}{R}\,[E + FR] = U \text{ (radial velocity component)}$$

$$WSV = \frac{TTY}{WS}\,[WSA] \equiv \frac{Y}{R}\,[E + FR] = V \text{ (axial velocity component)}$$

Package (3) generates a rectangle from $X1 = 0$ to $X2 = 340$ cm and for $Y1 = 200$ to $Y2 = 440$ cm.

16 particles/cell and $YC = XC = 0$ (dot material)

$$\left.\begin{array}{l} \rho = 1 \times 10^{-3} \\ I = 0 \\ U = V = 0 \end{array}\right\} \text{Use FIT 1}$$

The values of the TABi, TABR and TABUV arrays are read in on the 51, 52, and 53 cards.

A card with a 2 in Column 1 completes the data for the TCLAM code.

A subroutine SETUP is available to generate the initial grid (bypasses this generator code TCLAM) if both the target and projectile are of the same density. In addition, the projectile must be a right cylinder, with all the ΔX's as constant, and all ΔY's constant.

OUTPUT FROM TCLAM

The output, to be written on a binary tape, from the TCLAM code is the entire Z block (defined below), all the cell quantities (the two velocity components, the mass and internal energy), and the cell dimensions and areas. In the case where it is a particle run, the particles (their two coordinates and mass) and the i and j of the cell where the particle is located) are also put onto the binary tape.

The normal system of units are the cm-g-shake, where the units of energy are jerks/g and the pressure in units of jerks/cm^3 (1 jerk = 10^{16} ergs and 1 shake = 10^{-8} sec).

The Z block or array contains the number of cells, the number of zones in both directions, and other necessary information to start the TOIL code. Below is a complete list of the Z block generated, which is then written on the binary output tape.

Z	Equiv.	Units	Description
1	PROB	-	Equals problem number, input to TCLAM.
2	CYCLE	-	Equals cycle number = 0.
3	DT	shake	Set to 0 by TCLAM.
4	PRINTS	-	Set to 0 by TCLAM.
5	PRINTL	-	Set to 0 by TCLAM.
6	DUMPT7	-	Set to 0 by TCLAM.
7	CSTOP	-	Set to 0 by TCLAM.
8	PIDY	-	Equals π = 3.1415927.
9	TMZ	grams	Total mass (X + .) generated by TCLAM.
10	GAM	-	If = 0. a cylindrical problem.
11	GAMD	-	Set to 0 by TCLAM.
12	GAMX	-	Set to 0 by TCLAM.
13	ETH	jerk	Total energy in system.
14	FFA	-	Set to 0 by TCLAM.
15	FFB	-	Set to 0 by TCLAM.
16	TMDZ	grams	Total mass (.) generated by TCLAM.
17	TMXZ	grams	Total mass (X) generated by TCLAM.
18	XMAX	cm	= X(iMAX).
19	TXMAX	cm	= 2.XMAX.
20	TYMAX	cm	= 2.YMAX (NOTE: YMAX is not in Z block).
21	AMDM	grams	= minimum mass/2. of the dot particles.
22	AMXM	grams	= minimum mass/2. of the X particles.
23	DNN	-	Set to 0 by TCLAM.
24	DMIN	-	Set to 0 by TCLAM.
25	FEF	-	Set to 0 by TCLAM.
26	DTNA	-	Set to 0 by TCLAM.

Z	Equiv.	Units	Description
27	CVIS	-	Set to 0 by TCLAM.
28	NPR	-	Set equal to 6 in TCLAM.
29	NPRi	-	TCLAM sets NPRi = N4 (check definition of N4(Z(54)).
30	NC	-	Fixed value of cycle number, set to 0 by TCLAM.
31	NPC	-	Used as indices in TCLAM.
32	NRC	-	Used as indices in TCLAM.
33	iMAX	-	Input to TCLAM = maximum number of zones in X direction for this run.
34	iMAXA	-	Equal iMAX + 1.
35	jMAX	-	Input to TCLAM = maximum number of zones in Y direction for this run.
36	jMAXA	-	= jMAX + 1.
37	KMAX	-	= (iMAX)(jMAX) + 1.
38	KMAXA	-	= KMAX + 1.
39	NMAX	-	= total number of particles + 1 that TCLAM has generated.
40	ND	-	= total number of dot particles + 1 that TCLAM has generated.
41	KDT	-	Set to 0 by TCLAM.
42	iXMAX	-	= iMAXA + 1.
43	NOD	-	Used as index.
44	NOPR	-	Set equal to N3 (Note definition of N3(Z(53)).
45	NiMAX	-	Set to 0 by TCLAM.
46	NjMAX	-	Set to 0 by TCLAM.
47	i1	-	Set to 0 by TCLAM.
48	i2	-	Set to 0 by TCLAM.
49	i3	-	Set to 0 by TCLAM.
50	i4	-	Set to 0 by TCLAM.
51	N1	-	= scratch tape number.
52	N2	-	= scratch tape number.
53	N3	-	= number of particle records of length N4 - 1 that TCLAM has generated.
54	N4	-	= number of particle records + 1 to be stored on each particle tape record.
55	N5	-	Set to 0 by TCLAM.

Z	Equiv.	Units	Description
56	N6	-	= number of particles on the last particle tape record.
57	N7	-	= binary tape designation number.
58	N8	-	Set to 0 by TCLAM.
59	N9	-	Set to 0 by TCLAM.
60	N10	-	Set to 0 by TCLAM.
61	N11	-	Set to 0 by TCLAM.
62	NRM	-	Set to 0 by TCLAM.
63	TRAD	-	Set to 0 by TCLAM.
64	XNRG	-	Set to 0 by TCLAM.
65	SN	-	Set to 0 by TCLAM.
66	DXN	-	Set to 0 by TCLAM.
67	RADER	-	Set to 0 by TCLAM.
68	RADET	-	Set to 0 by TCLAM.
69	RADEB	-	Set to 0 by TCLAM.
70	DTRAD	-	Set to 0 by TCLAM.
71	REZFCT	-	Set to 0 by TCLAM.
72	RSTOP	-	Set to 0 by TCLAM.
73	SHELL	-	A counter that may be used to distinguish between codes.
74	BBOUND	-	Set to 0 by TCLAM.
75	TOZONE	-	Set to 0 by TCLAM.
76	EDK	-	Set to 0 by TCLAM.
77	SBOUND	-	Set to 0 by TCLAM.
78	X1	-	Set to 0 by TCLAM.
79	X2	-	Set to 0 by TCLAM.
80	Y1	-	Set to 0 by TCLAM.
81	Y2	-	Set to 0 by TCLAM.
82	CABLN	-	Set to 0 by TCLAM.
83	VISC	-	Set to 0 by TCLAM.
84	T	-	Set to 0 by TCLAM.
85	GMAX	-	Set to 0 by TCLAM.
86	WSGD	-	Set to 0 by TCLAM.
87	WSGX	-	Set to 0 by TCLAM.

Z	Equiv.	Units	Description
88	GMADR	-	Set to 0 by TCLAM.
89	GMAXR	-	Set to 0 by TCLAM.
90	S1	-	Set to 0 by TCLAM.
91	S2	-	Set to 0 by TCLAM.
92	S3	-	Set to 0 by TCLAM.
93	S4	-	Set to 0 by TCLAM.
94	S5	-	Set to 0 by TCLAM.
95	S6	-	Set to 0 by TCLAM.
96	S7	-	Set to 0 by TCLAM.
97	S8	-	Used for storage of FIT number for each package in TCLAM.
98	S9	-	Set to 0 in TCLAM.
99	S10	-	Set to 0 in TCLAM.

Z(100) through Z(150) is set to 0 by TCLAM.

The printed output from TCLAM is as follows:

1. The problem number, iMAX and jMAX.
2. A table of the values of X(i) from $i = 1$ to iMAX.
3. A table of the values of Y(j) from $j = 1$ to jMAX.
4. A table of the values of DX(i) from $i = 1$ to iMAX.
5. A table of the values of DY(j) from $j = 1$ to jMAX.
6. A table of the area's (in the axial direction) from $i = 1$ to iMAX.
7. Following this preliminary printout of the grid quantities we have the following information printed out per package:
   (a) The package number and the number of particles per cell.
   (b) The 6 constants for the density, energy and velocity fits.
   (c) The type of geometry, generate or delete, followed by the coordinates of the geometry.
   (d) The minimum and maximum i and j values of the package in question.
   (e) The total number of particles, the type, and the total energy and mass in this package.

8. After all package information is edited, a statement will appear as follows: "There are no more packages." The total energy of the system is edited, followed by the total mass and particles. A statement "Tape dump at time 0" appears next. This indicates that the binary tape was written successfully.

9. An edit of each column of the occupied grid appears next. This contains the X, DX for the column, and the Y, DY, U, V, AiD, AiX, AMD and AMX as a function of j. This completes the printed output from the TCLAM code.

B. TOIL

BASIC EQUATIONS

The Eulerian equations we wish to solve are the following:

$$\text{(A)} \quad \frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \vec{u}) = 0.$$

$$\text{(B)} \quad \frac{\partial \rho \vec{u}}{\partial t} + \nabla \cdot (\rho \overrightarrow{uu}) = - \nabla P$$

$$\text{(C)} \quad \frac{\partial \rho E}{\partial t} + \nabla \cdot (\rho E \vec{u}) = - \nabla \cdot (P \vec{u})$$

Equation (A) is the conservation of mass equation (B) is the conservation of momentum, and (C) is the conservation of energy equation.

The second terms on the left side of Eqs. (B) and (C) are temporarily dropped. Their contributions are later approximated when we move mass across cell boundaries.

Rewriting Eqs. (A), (B), and (C) in cylindrical coordinates with axis of symmetry results in Eqs. (1), (2), (3), and (4).

$$\frac{\partial \rho}{\partial t} = - \frac{\partial r \rho u}{r \partial r} - \frac{\partial \rho v}{\partial z} \tag{1}$$

$$\rho \frac{\partial u}{\partial t} = - \frac{\partial P}{\partial r} \tag{2}$$

$$\rho \frac{\partial v}{\partial t} = - \frac{\partial P}{\partial z} \tag{3}$$

$$\rho \frac{\partial E}{\partial t} = - \frac{\partial r P u}{r \partial r} - \frac{\partial P v}{\partial z} \tag{4}$$

$$P = f(\rho, I) \text{ Equation of State} \tag{5}$$

ρ = density of cell (K) in g/cm^3,

r = r coordinate in cm,

z = z coordinate in cm,

u = radial component of velocity in cm/shake,

v = axial component of velocity in cm/shake,

P = material pressure in jerks/cm^3,

E = total specific energy in jerks/g,

I = specific internal energy in jerks/g (1 jerk = 10^{16} ergs), and

t = time in shakes (1 shake = 10^{-8} sec).

The five variables listed are all located at the center of the cell.

Rewriting Eq. (4):

$$\rho \frac{\partial}{\partial t} [I + \tfrac{1}{2} (u^2 + v^2)] = - \frac{\partial rPu}{r\partial r} - \frac{\partial Pv}{\partial z}$$

or

$$\rho \frac{\partial I}{\partial t} + \rho u \frac{\partial u}{\partial t} + \rho v \frac{\partial v}{\partial t} = - \frac{P}{r} \frac{\partial ur}{\partial r} - u \frac{r\partial P}{r\partial r} - v \frac{\partial P}{\partial z} - P \frac{\partial v}{\partial z}$$

but

$$\rho \frac{\partial u}{\partial t} = - \frac{\partial P}{\partial r} \quad \text{and} \quad \rho \frac{\partial v}{\partial t} = - \frac{\partial P}{\partial z}$$

thus

$$\rho \frac{\partial I}{\partial t} = - P \left(\frac{\partial v}{\partial z} + \frac{1}{r} \frac{\partial ur}{\partial r} \right) .$$

This is then, the internal energy equation that we will integrate in the first phase of our calculations. As mentioned previously, the solution to the three equations is completed in two steps. The first step (called PH1 in TOIL), the momentum and energy equation as a function of the pressure forces only, are solved. Then in the second step (called PH2) we approximate those transport terms (convective terms) that we omitted in the first phase by transporting mass, momenta and energy across the cell boundaries.

In the discussion to follow, we approximate the partial differential equations by difference equations.

The radial momentum equation (2) becomes in difference form

$$\rho \frac{\partial u}{\partial t} = \frac{P_{i-3/2,\ j-1/2} - P_{i+1/2,\ j-1/2}}{2\ \Delta r_i}$$

and the axial momentum equation (3) becomes

$$\rho \frac{\partial v}{\partial t} = \frac{P_{j-3/2,\ i-1/2} - P_{j+1/2,\ i-1/2}}{2\Delta Z_j}$$

where the acceleration of a cell is only a function of its two neighbor cells (not of itself).

Defining

$$PL^n = \frac{P^n_{i-3/2} + P^n_{i-1/2}}{2.}$$

$$PRR^n = \frac{P^n_{i-1/2} + P^n_{i+1/2}}{2.}$$

$$\overset{n}{PBLO} = \frac{P^n_{j-3/2} + P^n_{j-1/2}}{2.}$$

$$\overset{n}{PABOVE} = \frac{P^n_{j-1/2} + P^n_{j+1/2}}{2.}$$

and substituting these interface pressures into the 2 momentum equations results in

$$\tilde{u}_{(i-1/2,\ j-1/2)} - u^n_{(i-1/2,\ j-1/2)} = \frac{\Delta t}{\rho_k{}^n}\left[\frac{PL^n - PRR^n}{\Delta r_i}\right]$$

where

$$k = i-1/2,\ j-1/2$$

or

$$\Delta u = \frac{2\pi\ \Delta t\ r_{i-1/2}\ Dy_j}{AMX_k}\left[PL^n - PRR^n\right]$$

and

$$\tilde{v_k} - v_k{}^n = \frac{\Delta t}{\rho_k{}^n}\left(\frac{\overset{n}{PBLO} - \overset{n}{PABOVE}}{\Delta z_j}\right)$$

Note ($\sim$) not n+1 is designated for the new velocities, since these changes are due to the pressure forces only.

$$\Delta v_k = \frac{\pi \, \Delta t(r_i^2 - r_{i-1}^2)(\overset{n}{\text{PBLO}} - \overset{n}{\text{PABOVE}})}{\text{AMX}_k}$$

and the change in specific internal energy becomes

$$\rho_k \frac{\partial \tilde{I}_k}{\partial t} = - P_k^n \left[\frac{v_{i-1/2,\ j+1/2}^{n+1/2} - v_{i-1/2,\ j-3/2}^{n+1/2}}{2\Delta Z_j} + \frac{r_{i+1/2}\, u_{i+1/2,\ j+1/2}^{n+1/2} - r_{i-3/2}\, u_{i-3/2,\ j-1/2}^{n+1/2}}{2 r_{i-1/2}\, \Delta r_i} \right]$$

The reason for the velocities at time n+1/2 is apparent for energy conservation.

Defining

$$u_{i-1/2,j-1/2}^{n+1/2} = \frac{\tilde{u}_{i-1/2,\ j-1/2} + u_{i-1/2,j-1/2}^{n}}{2.}$$

and

$$v_{i-1/2,j-1/2}^{n+1/2} = \frac{\tilde{v}_{i-1/2,j-1/2} + v_{i-1/2,j-1/2}^{n}}{2.}$$

and

$$\text{VBLO} = \frac{v_{j-1/2} + v_{j-3/2}}{2.}$$

$$\text{VABOVE} = \frac{v_{j-1/2} + v_{j+1/2}}{2.}$$

where VBLO, VABOVE, UL and URR are calculated at time n and $\sim$, and

$$\text{UL} = \frac{u_{i-1/2}\, r_{i-1/2} + u_{i-3/2}\, r_{i-3/2}}{2.}$$

and

$$URR = \frac{u_{i-1/2}\, r_{i-1/2} + u_{i+1/2}\, r_{i+1/2}}{2.}$$

then

$$\rho \frac{\partial \tilde{I}}{\partial t} = P^n \left[\frac{\overset{n}{VBLO} + \widetilde{VBLO}}{2\Delta Z_j} - \frac{\overset{n}{VABOVE} + \widetilde{VABOVE}}{2.\Delta Z_j} \right.$$

$$\left. - \frac{URR^n + URR^{\sim} - UL^n - UL^{\sim}}{2r_{i-1/2}\, \Delta r_i} \right]$$

or

$$\tilde{I}_{i-1/2,j-1/2} = I^n_{i-1/2,j-1/2} + \frac{\Delta t\, P^n_{i-1/2,j-1/2}}{AMX_{i-1/2,j-1/2}}$$

$$\left[\left(\frac{\overset{n}{VBLO} + \widetilde{VBLO}}{2.} - \frac{\overset{n}{VABOVE} + \widetilde{VABOVE}}{2.} \right) \pi \left(r_i^2 - r_{i-1}^2 \right) \right.$$

$$\left. + \left(-\overset{n}{URR} - \widetilde{URR} + UL_j^n + UL_j^{\sim} \right) \pi\, \Delta Z_j \right]$$

where again

$$k = i\text{-}1/2,\ j\text{-}1/2\ .$$

The change in internal energy for the entire cell is

$$\Delta Q = \Delta t\ (\mathrm{Vol})\ P \left[\frac{\partial v}{\partial z} + \frac{1}{r} \frac{\partial ru}{\partial r} \right] .$$

The change in specific internal energy for each material is proportional to the density of each material, or

$$\Delta I_x = \frac{\Delta Q}{f} \frac{1}{\frac{M_x}{f} + \frac{M_{\bullet}}{1-f}}$$

and

$$\Delta I_{\bullet} = \frac{\Delta Q}{1-f} \frac{1}{\frac{M_x}{f} + \frac{M_{\bullet}}{1-f}}$$

where (x) and (·) refer to the two different materials and f is the factor to multiply times the volume of the total cell to calculate the volume occupied by (x) material. The factor f is calculated from the equation of state, where we iterate on the densities until the pressures of each material are the same.

The solution of the momentum equations provide no difficulties, however, the solution to the energy equation requires the velocities at two different time steps.

We have chosen to make two passes through this routine, the first pass to integrate the momentum equations, and formulate the interface velocities (using the old velocities for their contributions to the work term) and the second pass to bypass the momentum equations, and just compute the new interface velocities for their contribution to the work term.

Another choice might be to solve the equations in one pass through, looking ahead two cells above and two cells to the right.

As an example, we will look at the energy conservation, say, in the axial direction. The radial direction would be very similar.

Since we have dropped the transport terms, our integration of the momentum and energy equations have not been advanced to time (n+1). As customary, we designate the PHASE 1 velocities and energy as $\tilde{u}$, $\tilde{v}$ and $\tilde{I}$.

$$\tilde{v}_{j-1/2} = v^n_{j-1/2} + \frac{\Delta t}{\rho^n_{j-1/2}} \left[\frac{P^n_{j-3/2} - P^n_{j+1/2}}{2\,\Delta y_j} \right]$$

and

$$\tilde{I}_{j-1/2} = I^n_{j-1/2} + \frac{\Delta t\, P^n_{j-1/2}}{\rho^n_{j-1/2}} \left[\frac{\bar{v}_{j-3/2} - \bar{v}_{j+1/2}}{2\,\Delta y_j} \right]$$

where

$$\bar{v}_{j-3/2} = \frac{\tilde{v}_{j-3/2} + v^n_{j-3/2}}{2.}$$

$$\bar{v}_{j+1/2} = \frac{\tilde{v}_{j+1/2} + v^n_{j+1/2}}{2.}$$

Before entering PH1, where the quantities are at time n, the total energy of the system (again, we are referring to the axial direction only) is

$$E^n = \sum_{j=1}^{jMAX} MASS_{j-1/2} \left[I^n_{j-1/2} + \tfrac{1}{2}\left(v^n_{j-1/2}\right)^2\right]$$

and the total energy at the end of Phase 1 is then

$$\tilde{E} = \sum_{j=1}^{jMAX} MASS_{j-1/2} \left[\tilde{I}_{j-1/2} + \tfrac{1}{2}\left(\tilde{v}_{j-1/2}\right)^2\right]$$

the total change being $\Delta E = E^n - \tilde{E}$ should be equal to 0. for energy conservation.

$$\Delta E = \sum_{j=1}^{jMAX} MASS_{j-1/2} \left[I^n_{j-1/2} - \tilde{I}_{j-1/2} + \tfrac{1}{2}\left(v^n_{j-1/2}\right)^2 - \tfrac{1}{2}\left(\tilde{V}_{j-\frac{1}{2}}\right)^2\right]$$

the Δ kinetic terms can be represented by

$$\frac{\left[v^n_{j-1/2} + \tilde{v}_{j-1/2}\right]}{2.} \left[v^n_{j-1/2} - \tilde{v}_{j-1/2}\right]$$

or

$$\bar{v}_{j-1/2} \left(v^n_{j-1/2} - \tilde{v}_{j-1/2}\right)$$

or

$$\Delta E = \sum_{j=1}^{jMAX} MAXX_{j-1/2} \left[I^n_{j-1/2} - \tilde{I}_{j-1/2} + \bar{v}_{j-1/2}\left(v^n_{j-1/2} - \tilde{v}_{j-1/2}\right)\right]$$

$$= \sum_{j=1}^{jMAX} MASS_{j-1/2} \left[- \frac{\Delta t\, P^n_{j-1/2}}{\rho^n_{j-1/2}} \left(\frac{\bar{v}_{j-3/2} - \bar{v}_{j+1/2}}{2\Delta y_j}\right)\right.$$

$$\left. - \bar{V}_{j-1/2}\left(\frac{\Delta t}{\rho^n_{j-1/2}} \frac{\left(P^n_{j-3/2} - P^n_{j+1/2}\right)}{2\Delta y_j}\right)\right]$$

$$= \Delta t \sum_{j=1}^{jMAX} \frac{MASS_{j-1/2}}{\rho^n_{j-1/2}{}^2\, \Delta y_j} \left[- P^n_{j-1/2}\, \bar{v}_{j-3/2} + P^n_{j-1/2}\, \bar{v}_{j+1/2}\right.$$

$$- P^n_{j-1/2}\,\bar{v}_{j-1/2} + P^n_{j+1/2}\,\bar{v}_{j-1/2}\Big]$$

(A)
$$= -\frac{\Delta t}{2}\sum_{j=1}^{jMAX}\pi\left(r_i^2 - r_{i-1}^2\right)\Big[P^n_{j-1/2}\,\bar{v}_{j-3/2} + P^n_{j-3/2}\,\bar{v}_{j-1/2}$$

$$- P^n_{j+1/2}\,\bar{v}_{j-1/2} - P^n_{j-1/2}\,\bar{v}_{j+1/2}\Big]$$

Thus the last two terms in j being cancelled by the first two terms in $j+1$. Now by prescribing the proper boundary conditions, we will have exact energy conservation for the entire grid.

EXAMPLE:

For $j = 1$

$$P_{1/2}\,v_{-1/2} + P_{-1/2}\,v_{1/2} - P_{3/2}\,v_{1/2} - P_{1/2}\,v_{3/2}$$

$j = 2$

$$P_{3/2}\,v_{1/2} + P_{1/2}\,v_{3/2} - P_{5/2}\,v_{3/2} - P_{3/2}\,v_{5/2}$$

$j = 3$

$$P_{5/2}\,v_{3/2} + P_{3/2}\,v_{5/2} - P_{7/2}\,v_{5/2} - P_{5/2}\,v_{7/2}$$

Thus we have non-cancellation of the first two and last two terms.

For our first example, assume the bottom boundary is reflective. Referring to Eq. (A) we have two terms that will not be cancelled as j increases, these terms are

$$P^n_{1/2}\,\bar{v}_{-1/2} + P^n_{-1/2}\,\bar{v}_{1/2}\;.$$

We set the pressure of the mirror cell

$$(P^n_{-1/2}) = P^n_{1/2}$$

(which does not imply that $\dot{v}_{1/2} = 0$.) The other condition which does lead to these two terms cancelling is that $v_{-1/2} = -\,v_{1/2}$. A similar treatment would be applied for the top boundary to be reflective.

Now, however, if we assume that the bottom boundary is transmittive, our boundary conditions are then that $\dot{v}_{1/2} = 0.$ which means that

$$P^n_{-1/2} = P^n_{3/2} .$$

The condition on the velocity is that $v_{-1/2} = v_{1/2}$. Now this leaves us with the first two terms $P_{1/2}\, v_{1/2} + P_{3/2}\, v_{1/2}$. This term then is adding or subtracting energy to the system (depends on sign of velocity). To compensate, or a better word to use might be to keep the books straight, we also add this term to the quantity called Eth.

Eth is defined as the total energy at time = 0., less the energy lost by mass leaving the grid + the energy added if negative interval energies appear in the transport phase ± the energy loss or gain at the transmittive boundary conditions in PH1.

A similar prescription would apply for the top boundary being transmittive. The conservation of energy in the radial direction follows the same logic and will not be repeated.

The term subtracted from Eth for the boundary at the right is

$$\frac{P_{(k)} + P_{(\text{cell to the left})}}{2.}\, u_{(k)}\, r_{i-\frac{1}{2}}\, \pi \Delta t DY_{(j)}$$

and the top is

$$\frac{P_{(k)} + P_{(\text{cell below})}}{2.}\, v_{(k)}\, \pi(r_i^2 - r_{i-1}^2)\, \Delta t(.5)$$

and the bottom, if transmittive, is

$$\frac{P_{(k)} + P_{(\text{cell above})}}{2.}\, v_{(k)}\, \pi(r_i^2 - r_{i-1}^2) \Delta t(.5)$$

and is added to ETH. K (in the above equations) refers to the border cell.

The left boundary (axis of symmetry) is always reflective, the bottom may be reflective or transmittive and the top and right are always transmittive.

Rewriting Eq. (1), the mass transport equation in finite difference form results in

$$\frac{\rho^{n+1}_{(k)} - \rho^{n}_{(k)}}{\Delta t} = \frac{r_{i-1}\,\rho_{i-1}\,u_{i-1}}{r_{i-\frac{1}{2}}\,\Delta r_i} - \frac{r_i \rho_i u_i}{r_{i-\frac{1}{2}}\,\Delta r_i} + \frac{\rho_{j-1}\,v_{j-1} - \rho_j\,v_j}{\Delta z_{(j)}} \tag{6}$$

where

$$\Delta z_{(j)} = \frac{V_{(k)}}{A^z_j} = \frac{V_{(k)}}{A^z_{j-1}}$$

where A^z for all $j = \pi(r^2_{(i)} - r^2_{(i-1)})$, and

$$V_{(k)} = \text{volume of cell } k = 2\pi\, r_{i-\frac{1}{2}}\,\Delta r_i\,\Delta z_{(j)} \tag{7}$$

multiply both sides of Eq. (7) by r_i results in

$$V_{(k)}\,r_i = 2\pi r_i\,\Delta Z_j\,r_{i-\frac{1}{2}}\,\Delta r_i$$

or

$$V_{(k)}\,r_i = A^r_i\,r_{i-\frac{1}{2}}\,\Delta r_i \tag{8}$$

where A^r = area in the direction perpendicular to the Z axis. And similarly, multiplying Eq. (7) by r_{i-1} results in

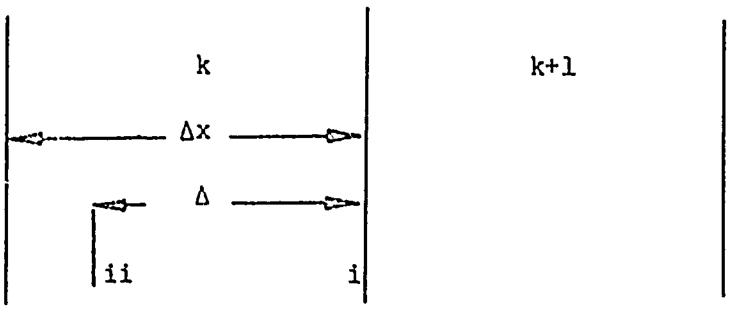
$$V_{(k)}\,r_{i-1} = 2\pi r_{i-1}\,\Delta Z_j\,r_{i-\frac{1}{2}}\,\Delta r_i$$

or

$$V_{(k)}\,r_{i-1} = A^r_{i-1}\,r_{i-\frac{1}{2}}\,\Delta r_i \tag{9}$$

Solving Eqs. (8) and (9) for $r_{i-\frac{1}{2}}\,\Delta r_i$ and substituting their values into Eq. (6) results in

$$\frac{\rho^{n+1}_{(k)} - \rho^{n}_{(k)}}{\Delta t} = \frac{1}{V_{(k)}}\left(A^z_{j-1}\rho_{j-1}v_{j-1} - A^z_j\rho_j v_j + A^r_{i-1}\rho_{i-1}u_{i-1} - A^r_i\rho_i u_i\right) \quad .$$



The mass to move across i is between i and ii where $\Delta = i - ii$; thus $\Delta = \tilde{u}\Delta t$ where $\tilde{u}$ is the weighted velocity at Δ. Using the first two terms of the Taylor series at a distance of $-\Delta$ from i, we expand

$$u_{(i)} = \frac{u_{(k)} + u_{(k+1)}}{2.}$$

or

$$\tilde{u} = \frac{u_{(k)} + u_{(k+1)}}{2.} + (-\Delta)\,\frac{(u_{(k+1)} - u_{(k)})}{\Delta x}$$

or

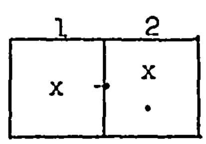
$$\frac{\Delta}{\Delta t} = \tilde{u} = \frac{\dfrac{u_{(k)} + u_{(k+1)}}{2.}}{\dfrac{(u_{(k+1)} - u_{(k)})\,\Delta t}{\Delta x} + 1}$$

If $u_{(k)} + u_{(k+1)}/2. > 0$ use $\rho_{(k)}$; otherwise use $\rho_{(k+1)}$ in the calculation of the mass flux. The density (ρ) is the total mass (x and dot) over the volume of the cell.

Mass, both components of momentum, and the energy across all four sides of the cell for both materials are calculated. By conserving both axial and radial momentum and the total energy, the new velocities are calculated and the new internal energy is then the difference between the total and the kinetic. Thus, up to this point, we have calcaulted the mass fluxes, now we must determine (for a mixed cell) how much of each material to move. Three possible situations concerned with two materials arise.

1. Material moving from a non-mixed cell to a mixed cell. This presents no difficulty or modification.

   Example (non-mixed to mixed)



Mass flow is from cell 1 to cell 2.

$$\Delta M = \rho^{1}\,\overline{U}\,A\,\Delta t$$

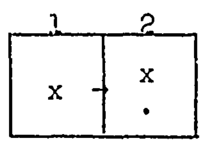
$$\Delta M_x = \Delta M$$

$$\Delta M_{\bullet} = 0$$

where ρ^1 = density of x material in cell 1.

2. Material moving from a mixed cell to a non-mixed cell is calculated as follows: The acceptor material from the donor cell is moved to the acceptor cell. If the flux is such that this will more than empty the acceptor material from the donor cell, the excess is removed by assigning it to the other material.

Example (mixed to non-mixed)



Mass flow is from cell 1 to cell 2.

$\Delta M = \rho^1 \bar{U} A \Delta t$ where ρ^1 is the total density of both materials in cell 1 if $\Delta M > M^1$.

$$\Delta M_{\bullet} = M^1_{\bullet}$$

and

$$\Delta M_x = \Delta M - M^1_{\bullet}$$

if $\Delta M \leq M^1_{\bullet}$

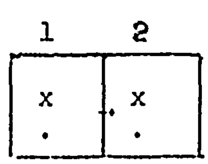
$$\Delta M_{\bullet} = \Delta M$$

and

$$\Delta M_x = 0 \quad .$$

3. Material moving from a mixed cell to a mixed cell requires some modification in order to keep the material interface defined in a single mixed cell. The prescription of recipe if you like, is that each material flux is weighted by the fraction of its mass to total in the acceptor cell, rather than the donor cell.

Example (mixed to mixed)



Mass flow is from cell 1 to cell 2.

$\Delta M = \rho^1 \bar{U} A \Delta t$, where ρ^1 is the total density of both materials in cell 1. Then

$$\Delta M_x = \frac{M_x^2}{M_x^2 + M_{\cdot}^2} \Delta M$$

and

$$\Delta M_{\cdot} = \frac{M_{\cdot}^2}{M_x^2 + M_{\cdot}^2} \Delta M \quad .$$

Note: The superscripts refer to zone number of the subscript to material number.

Several techniques are available for calculating the specific internal energy of a mixed cell.

The scheme as reported in the listings of TOIL is as follows. The specific internal energy for each material is proportional to the specific total energy of that material (the total specific energy of the cell plus that which is transported in less the amount transported out).

$$\Delta E_x = \Sigma M_x \left[\tilde{I}_x + \frac{\tilde{U}^2 + \tilde{V}^2}{2.} \right]$$

$$\Delta E_{\cdot} = \Sigma M_{\cdot} \left[\tilde{I}_{\cdot} + \frac{\tilde{U}^2 + \tilde{V}^2}{2.} \right] \quad .$$

Where the ($\sim$) tilda refers to the velocities and specific internal energy after (PH1).

$M_x^{n+1} = \Delta M_x$ = total mass of cell plus that which is transported in less the amount transported out for the x material.

$M_{\cdot}^{n+1} = \Delta M_{\cdot}$ = similar term for the dot material.

Then the new internal energy for the mixed cell is

$$Q = \Delta E_{\cdot} + \Delta E_x - \tfrac{1}{2} \left(U_{n+1}^2 + V_{n+1}^2 \right) (\Delta M_x + \Delta M_{\cdot}) \quad .$$

Thus each material then has the following specific internal energy

$$I_x^{n+1} = \frac{\Delta E_x}{\Delta M_x} \frac{Q}{\Delta E_x + \Delta E_.}$$

$$I_.^{n+1} = \frac{\Delta E_.}{\Delta M_.} \frac{Q}{\Delta E_x + \Delta E_.} \quad .$$

Several other techniques are available.

(1) The change in specific internal energies being proportional to the mass, or

$$\frac{\Delta I_x}{\Delta I_.} = \frac{M_x}{M_.}$$

where ΔQ = change in internal energy either due to the work terms in PH1 or the transport terms in PH2.

Then $M_x \Delta I_x + M_. \Delta I_. = \Delta Q$

or

$$\Delta I_x = \frac{M_x \Delta Q}{M_x^2 + M_.^2}$$

and

$$\Delta I_. = \frac{M_. \Delta Q}{M_x^2 + M_.^2} \quad .$$

(2) The change in internal energy for each material to be the same

or

$$M_x \Delta I_x = M_. \Delta I_.$$

and

$$M_x \Delta I_x + M_. \Delta I_. = \Delta Q$$

or

$$\Delta I_x = \frac{\Delta Q}{2M_x}$$

and

$$\Delta I_. = \frac{\Delta Q}{2M_.} \quad .$$

(3) The change in specific internal energy for each material to be the same

$$\Delta I_x = \Delta I_.$$

and

$$M_x \, \Delta I_x + M_. \, \Delta I_. = \Delta Q$$

or

$$\Delta I_x = \frac{\Delta Q}{M_x + M_.} = \Delta I_. \quad .$$

C. NORMAL INPUT FOR THE TOIL CODE

An (*) designates that the work is fixed point (a 2 in Column 1) although all words are loaded via card routine in floating format. (A **, double asterisk signifies this is last card of the set.)

1st Set--Column 1-3--contains N (the number of BCD cards to follow (format I3) N BCD cards.

2nd Set

LOC	Name	Description
*57	N7	Binary tape dump number.
**282	PK array	PK(1) = problem number PK(2) = cycle number to start problem PK(3) = -1, for restart or starting from the TCLAM tape PK(3) = 0, starting problem at t = 0, via subroutine SETUP.

3rd Set

LOC	Name	Description
14	FFA	See usage as described in OIL report.
15	FFB	See usage as described in OIL report.
24	DMIN	$\sim 10^{-6}$ energy check $\Delta E/E$/cycle.
25	FeF	Δ .03, used in iteration routine for calculating pressures in a mixed cell.
27	CVIS	Bottom boundary condition. If < 0 transmittive otherwise reflective.
*47	i1	Active grid counter in the i direction (= the i value of the right most cell(that has internal or kinetic energy)+ 2).
*48	i2	Similar to i1 but for the j direction.

LOC	Name	Description
*51	N1	~ 20, the maximum number of iterations allowed for calculating the pressure of a mixed zone.
77	SBOUND	Same value as for OIL ~ 1.0.
71	REZFCT	PH2 routine always will check for the amount of material (TOZONE) leaving the top or right boundaries. It may trigger REZONE (sets REZ = 1.). At the completion of PH2, if REZ = 1. a further check is done, using REZFCT (if = 1.) code will call the subroutine REZONE, otherwise it will ignore the flag set in PH2.
75	TOZONE	The mass flux at a interior free surface is set to 0. unless the flux produces a density > TOZONE, if so mass is allowed to move.
82	CABLN	See usage as described in the OIL report.
86	GAMMA	(For dot material.)
87	GAMMA	(For x material.)
105	Z(105)	Fraction of stability for early times if the initial energy is primarily internal, rather than kinetic (~ .05).
106	Z(106)	Factor to increase Z(105)/cycle to build up its value to the normal value located in Z(139).
107	Z(107)	ρ^x_{min} Minimum density of x material allowed in any cell.
108	Z(108)	$\dot{\rho}_{min}$ Minimum density of . material allowed in any cell.
111	Z(111)	Density of (.) material to add on to target for REZONE (hypervelocity type calculations).
112	Z(112)	Initial (Z component) projectile velocity in cm/shake.
113	Z(113)	ε (epsilonics) for emptying the bottom cells of the projectile up until the reflected shock reaches the bottom surface of the projectile.

LOC	Name	Description
115	ρ_0^x	The superscripts refer to the material. The definitions and numerical values for different material are the same as in the OIL report.
116	$\rho_0^{\cdot}$	
117	a^x	
118	$a^{\cdot}$	
119	E_0^x	
120	$E_0^{\cdot}$	
121	b^x	The superscripts refer to the material, the definitions and numerical values for the different materials are the same as in the OIL report.
122	$b^{\cdot}$	
123	A^x	
124	$A^{\cdot}$	
125	V_s^x	
126	$V_s^{\cdot}$	
127	E_s^x	
128	$E_s^{\cdot}$	
129	α^x	
130	$\alpha^{\cdot}$	
131	β^x	
132	$\beta^{\cdot}$	
133	B^x	
134	$B^{\cdot}$	
138	Z(138)	Minimum density that a cell must have such that a stability check will be performed on it.
139	Z(139)	Fraction of stability (~ .5).
143	Z(143)	= minimum density of the dot (.) material allowable to transport across a cell or to remain in a cell ($\sim 10^{-3}\,\rho_0^{\cdot}$).

LOC	Name	Description
144	Z(144)	= similar term for the x material.
145	Z(145)	= ϵ (epsilonics) on the specific internal energy. If Aix or AiD < Z(145), Aix or AiD is set to 0. and the books are balanced.
146	Z(146)	= ϵ (epsilonics) on the 2 velocity component. If $\lvert u \rvert$ or $\lvert v \rvert$ < Z(146), u or v are set to 0. and the books are balanced.
148	C_0	$C = C_0 + AP^{\epsilon}$ Where the units of C_0 and A are 10^5 cm/sec and P is in megabars. CDT routine converts (C) speed of sound to cm/shake.
149	A	
150	ϵ	
**3	DT	See usage and definitions as described in the OIL report.
4	PRINTS	
5	PRINTL	
6	DUMPT7	
7	CSTOP	

If one uses the subroutine SETUP for generating the initial configuration, the following data cards must be added to the 3rd set, and a 4th set must be added, usually duplicate the last card of the 3rd set. Subroutine SETUP implies certain restrictions as stated:

1. Constant DX and constant DY,
2. The projectile is a right circular cylinder,
3. The projectile has kinetic (Z component only) energy only.

LOC	Name	Description
285	PK(4)	Set = 1.
286	PK(5)	Right boundary of projectile (i).
287	PK(6)	Bottom (j) + 1 of projectile.
288	PK(7)	Top (j) of projectile.

LOC	Name	Description
289	PK(8)	= 1.
290	PK(9)	Right (i) boundary of target.
291	PL(10)	Bottom (j) + 1 of target.
292	PK(11)	Top (j) of target.
23389	DX(1)	DX, to be used for all (i).
23489	DY(1)	DY, to be used for all (j).
1	PROB	The problem number.
*33	iMAX	The maximum number of zones in the i direction.
*35	jMAX	The maximum number of zones in the j direction.
		NOTE: (iMAX)(jMAX) must be $\leqq$ 4499.
*57	N7	The binary tape number.

D. TOIL (TWO MATERIAL)

Symbol	Loc	No. of Words	Units	Description
AiD	5253	4500	jerks/g	Specific internal energy in jerks/g of cell K (for . material).
AiX	9753	4500	jerks/g	Specific internal energy in jerks/g of cell K (for X material).
AM	14253	130	many	Equivalenced to DMASL in PH2 and used for partial editing in EDIT.
AMD	14383	4500	grams	Mass in grams of cell K for (.) material.
AMDM	23	1	grams	Not used in TOIL. Set = minimum (.) particle mass/2. in TCLAM.
AMK	267	15	many	Used in EDIT, also equivalenced to UR(16).
AMX	18883	4500	grams	Mass in grams of cell K for (X) material.
AMXM	22	1	grams	Not used in TOIL. Set = minimum (X) particle mass/2. in TCLAM.
AREA	23383	1	-	Not used.
BBOUND	74	1	-	Not used.
BIG	23384	1	-	Not used.
BOUNCE	23385	1	-	Not used.
CABLN	82	1	-	Same definition as in OIL code.
CSTOP	7	1	-	Cycle number at which problem will stop, edits and writes dump tape.
CVIS	27	1	-	If -, bottom boundary is transmittive, otherwise reflective.

Symbol	Loc	No. of Words	Units	Description
CYCLE	2	1	1	Cycle number.
DDVK	23387	1	-	Not used.
DDXN	23386	1	-	Not used.
DENRG	37539	130	jerks	Equivalenced to iW1, used in PH2 transport array for (.) fluxes.
DKE	652	4500	-	Partial volume of (X) material in a mixed cell, fraction of.
DMASL	14253	130	grams	Equivalenced to AM, used in PH2 transport array for (.) left flux.
DMIN	24	1	-	For energy check $\sim 10^{-6}$.
DNN	23	1	-	= (ETH - E)/ETH at the last energy check cycle.
DT	3	1	shakes	Δt^{n+1} (hydro time step).
DTNA	26	1	shakes	Δt^{n} (old hydro time step).
DTRAD	70	1	shakes	Not used in TOIL, reserved for radiation, although calculated in CDT.
DUMPT7	6	1	-	Frequency in cycles at which code will make a binary tape dump.
DVK	23388	1	-	Not used.
DX	23389	100	cm	DX(i) = X(i) - X(i - 1).
DXML	37264	130	g-cm-shake	Equivalenced to XL in PH2, contains the (.)(X) component of momentum at the left.
DXN	66	1	-	Not used.
DY	23489	100	cm	DY(j) = Y(j) - Y(j - 1).
DYML	36885	130	g-cm-shake	Equivalenced to YL array in PH2. Contains Y component of momentum at left for (.) material.
E	23589	1	jerks	Used in REZONE as total energy of new cell.

Symbol	Loc	No. of Words	Units	Description
ECK	76	1	-	Energy check = $\dfrac{\dfrac{ETH^{n}-E^{n}}{ETH^{n}} - \dfrac{ETH^{n-m}-ETH^{n-m}}{ETH^{n-m}}}{M}$
ETH	13	1	jerks	Total energy of system less any that leaves or adjustments at transmittive grid boundaries.
FD	23590	1	-	Not used.
FEF	25	1	-	ϵ factor in ES.
FFA	14	1	-	Upper limit for stability and to calculate Δt only if CABLN = 0.
FFB	15	1	-	Lower limit for stability and to calculate Δt only if CABLN = 0.
FLEFT	252	100	grams	Used in PH2 as X mass at left boundary.
FS	23591	1	-	Used in PH1, PH2, independent of each.
FX	23592	1	-	Not used.
GAM	10	1	-	Not used.
GAMC	452	1	many	Equivalenced to PL of PR.
GAMD	11	1	-	1./(γ.-1.) Used for gamma law equation of state.
GAMX	12	1	-	1./(γX-1.) Used for gamma law equation of state.
GMADR	88	1	-	γ./(γ.-1) Calculated but not used.
GMAX	85	1	-	Maximum gamma.
GMAXR	89	1	-	γX/(γX-1.) Calculated, but not used.
I	37531	1	-	Index in X direction.
II	37532	1	-	Working index, used in INPUT.

Symbol	Loc	No. of Words	Units	Description
IMAX	38	1	-	Maximum number of zones in the X direction.
IMAXA	34	1	-	= iMAX + 1, never used.
IN	37533	1	-	Not used.
IR	37534	1	-	Not used.
IWS	37535	1	-	Used as working storage in INPUT and CDT.
IWSA	37536	1	-	Not used.
IWSB	37537	1	-	Not used.
IWSC	37538	1	-	Not used.
IW1	37539	130	many	Equivalenced to DENRG.
IXMAX	42	1	-	Calculated as iMAX = 2 in TCLAM, never used. SETUP does not calculate it.
IZ	7	150	many	Fixed point. Block equivalenced to Z.
I1	47	1	-	Active grid counter in X direction, maximum value = iMAX.
I2	48	1	-	Active grid counter in Y direction, maximum value = jMAX.
I3	49	1	-	Not used.
I4	50	1	-	Not used.
J	37669	1	-	Index in Y direction (temporary).
jMAX	35	1	-	Maximum number of zones in the Y direction.
jMAXA	36	1	-	= jMAX + 1, never used.
JN	37670	1	-	Not used.
JP	37671	1	-	Not used.
JR	37672	1	-	Not used.

Symbol	Loc	No. of Words	Units	Description
K	37673	1	-	Index of center of cell, defined as = (j-i) iMAX + i + 1.
KDT	41	1	-	Flag in CDT to signal print re-work DT has changed.
kMAX	37	1	-	= (iMAX)(jMAX) + 1.
kMAXA	38	1	-	= kMAX + 1.
KN	37674	1	-	Not used.
KP	37675	1	-	Index in PH2 (temporary).
KR	37676	1	-	Not used.
KRM	37677	1	-	Not used.
L	37678	1	-	Index (temporary).
M	37679	1	-	Index (temporary).
MA	37680	1	-	Index (used in SETUP).
MB	37681	1	-	Index (used in SETUP).
MC	37682	1	-	Index (used in SETUP).
MD	37683	1	-	Index (used in SETUP).
ME	37684	1	-	Index (used in SETUP).
MZ	37685	1	-	Index (used in SETUP).
N	37686	1	-	Index (temporary).
NC	30	1	-	Fixed point value of cycle number
ND	40	1	-	Used temporarily in PH2.
NIMAX	45	1	-	= iMAX/2 calculated in REZONE.
NJMAX	46	1	-	= jMAX/2 calculated in REZONE.
NK	37687	1	-	Index in EDIT.
NKMAX	37688	1	-	Not used.
NK1	37689	1	-	Index in EDIT.

Symbol	Loc	No. of Words	Units	Description
NMAX	39	1	-	Flag for stability check in radial direction (PIC or OIL).
NO	37690	1	-	Not used.
NOD	43	1	-	Not used.
NOPR	44	1	-	Not used.
NPC	31	1	-	Number of cycles between energy checks.
NPR	28	1	-	Not used.
NPR1	29	1	-	Not used.
NR	37691	1	-	Identification of routine when a dump is called.
NRC	32	1	-	Used as flag for advancing active grid counters in PH1 and PH2.
NRM	62	1	-	For radiation option, is the maximum number of radiation cycles per hydro.
N1	51	1	-	Maximum number of iterations for mixed cell pressure.
N10	60	1	-	= i of zone controlling time step.
N11	61	1	-	= j of zone controlling time step.
N2	52	1	-	Not used.
N3	53	1	-	Set = 0 in TCLAM.
N4	54	1	-	Not used.
N5	55	1	-	Not used.
N6	56	1	-	Not used.
N7	57	1	-	Binary tape number.
N8	58	1	-	Not used.
N9	59	1	-	Not used.

Symbol	Loc	No. of Words	Units	Description
OUT	23593	1	-	Not used.
P	23594	4500	jerks/ cm^3	Pressure of cell K.
PABOVE	28094	1	jerks/ cm^3	= [P(K) + P(cell above)]/2. PH1.
PBLO	28095	1	jerks/ cm^3	= [P(K) + P(cell below)]/2. PH1.
PIDTS	28096	1	many	= $1./\pi\Delta t\Delta y$ in PH1; $1./\pi\Delta t$ in PH2.
PIDY	8	1	-	π.
PK	282	15	many	Used for inputing starting data.
PL	452	200	many	Used in PH1 and PH2.
PPABOV	28097	1	-	Not used.
PR	452	200	many	Used in PH1 and PH2.
PRINTL	5	1	cycles	Number of cycles between long prints.
PRINTS	4	1	cycles	Number of cycles between short prints.
PROB	1	1	-	Problem number.
PRR	28098	1	jerks/ cm^3	= [P(K) + P(cell to right)]/2. PH1.
PUL	28099	1	-	Not used.
QDT	28100	1	-	Not used.
QK	297	15	g-cm-shake	Axial momentum in selected angles.
QOOOFL	28107	1	-	Not used.
RADEB	69	1	-	Not used.
RADER	67	1	g-cm-shake	Total positive radial momenta for X material.
RADET	68	1	g-cm-shake	Total positive axial momenta for X material.
RC	28101	1	cm	= [X(i) + X(i-1)]/2. in PH1.

Symbol	Loc	No. of Words	Units	Description
REZ	28102	1	-	If mass leaves top, right or bottom, REZ set > 0.
REZFCT	71	1	-	If REZ (trigger in PH2) > 0 and REZFCT > 0 PH2 calls REZONE.
RHO	28103	1	-	Not used.
RL	28104	1	-	Not used.
RR	28105	1	cm	$= [X(i) + X(i+1)]/2.$ in PH1.
RSTOP	72	1	-	Not used.
SBOUND	77	1	-	Factor in velocity weighting PH2.
SHELL	73	1	-	Not used.
SIG	28106	1	cm	Minimum ΔX or ΔY in CDT routine.
SIGC	551	100	many	Used in PH1 and PH2.
SN	65	1	-	Not used.
SWITCH	28108	1	-	Not used.
S1	90	1	-	Not used.
S10	99	1	-	Not used.
S2	91	1	-	Not used.
S3	92	1	-	Not used.
S4	93	1	-	Not used.
S5	94	1	-	Not used.
S6	95	1	-	Not used.
S7	96	1	-	Not used.
S8	97	1	-	Not used.
S9	98	1	-	Not used.
T	84	1	shake	$t^n = t^{n-1} + \Delta t.$

Symbol	Loc	No. of Words	Units	Description
TAB	252	15	-	Tangent of 12 selected angles (EDIT).
TABLM	28109	1	-	Not used.
TAU	28110	100	cm^2	$TAU(i) = \pi(X_i^2 - X_{i-1}^2)$.
TAUDTS	28210	1	cm^2-shake	= TAU(i) * DT. (PH1)
TAUDTX	28211	1	-	Not used.
THETA	652	4500	-	Equivalenced to DKE array.
TMDZ	16	1	grams	= total (.) mass. (If TCLAM generates the data.)
TMXZ	17	1	grams	= total (X) mass. (If TCLAM generates the data.)
TMZ	9	1	grams	Total mass (X + .).
TOZONE	75	1	g/cm^3	If mass flux (across free surface) produces ρ < TOZONE, flux set to 0. PH2.
TRAD	63	1	shake	Δt radiation (not used in this version).
TXMAX	19	1	cm	2. * X(iMAX) never used.
TYMAX	20	1	cm	2. * Y(jMAX) never used.
U	28212	4500	cm-shake	Radial velocity component of cell K.
UK	32712	1	-	Not used.
UL	252	200	many	Arrays in PH1, PH2 of twice (jMAX).
UR	252	200	many	Arrays in PH1, PH2 of twice (jMAX).
URR	32713	1	cm^2-shake	[U(K) Xi-1/2 + U(K+L) Xi+1/2]/2.
UT	32714	1	-	Not used.
UTEF	32717	1	-	Not used.
UU	32715	1	-	Not used.

Symbol	Loc	No. of Words	Units	Description
UUU	32716	1	-	Not used.
UVMAX	32718	1	1/shake	Minimum $\lvert U \rvert$ or $\lvert V \rvert$/DX or DY. CDT.
V	32719	4500	cm/shake	Axial velocity component of cell K.
VABOVE	37219	1	cm/shake	= [V(K) + V(cell above)]/2. PH1.
VBLO	37220	1	cm/shake	= [V(K) + V(cell below)]/2. PH1.
VEL	37221	1	-	Flag PH1, PH2.
VISC	83	1	-	Not used.
VK	37222	1	-	Not used.
VT	37223	1	-	Not used.
VTEF	37224	1	cm/shake	Initial pellet velocity (Z(112)) if generating via subroutine SETUP.
VV	37225	1	-	Not used.
VVABOV	37226	1	-	Not used.
VVBLO	37227	1	-	Not used.
WPS	37259	1	-	Working storage.
WS	37260	1	-	Working storage.
WSA	37261	1	-	Working storage.
WSB	37262	1	-	Working storage.
WSC	37263	1	-	Working storage.
WSGD	86	1	-	γ.
WSGX	87	1	-	γX (input) ES atores .5 into it.
W2	37228	1	-	Not used.
W3	37258	1	-	Not used.

Symbol	Loc	No. of Words	Units	Description
X	152	100	cm	X(i) = right boundary of cell i.
XL	37264	130	-	Used temporarily in EDIT and PH2.
XLF	32394	1	-	Not used.
XMAX	18	1	cm	X(iMAX).
XN	37395	1	-	Not used.
XNRG	64	1	-	Not used.
XR	37396	1	-	Not used.
XX	151	101	cm	XX(i) = X(i-1) not used.
X1	78	1	-	Not used.
X2	79	1	-	Not used.
Y	5153	100	cm	Y(j), the top dimension of cell K.
YAMC	351	100	many	Used in PH1 and PH2.
YL	37397	130	many	Used temporarily in PH2 and EDIT.
YLW	37527	1	-	Not used.
YN	37528	1	-	Not used.
YU	37529	1	-	Not used.
YY	5152	101	cm	YY(2) = Y(1) not used.
Y1	80	1	-	Not used.
Y2	81	1	-	Not used.
Z	1	150	many	Definitions have been made.
ZMAX	37530	1	-	Not used.

Z BLOCK

Location	Symbol	Units	Description
Z(1)	PROB	-	Problem number (if positive, this is an OIL run; if negative, this is a PIC run.
Z(2)	CYCLE	-	Cycle number (floating point value).
Z(3)	DT	shake	Δt hydro = $t^n - t^{n-1}$.
Z(4)	PRINTS	-	Cycle frequency for short print.
Z(5)	PRINTL	-	Cycle frequency for long print.
Z(6)	DUMPT7	-	Cycle frequency for binary tape dumps.
Z(7)	CSTOP	-	Cycle number at which problem stops.
Z(8)	PIDY	-	= π = 3.1415927.
Z(9)	TMZ	grams	Total (X + .) mass at t = 0 (calculated in TCALM.
Z(10)	GAM	-	Not used.
Z(11)	GAMD	-	1./γ.-1) } Computed in INPUT.
Z(12)	GAMX	-	1./(γX-1) } Computed in INPUT.
Z(13)	ETH	jerks	Total energy (computed in TCLAM for t = 0). Changed in PH1 at transmittive boundaries and in PH2 if mass leaves the system, and by radiation flow out of the system.
Z(14)	FFA	-	Upper limit for stability and to calculate Δt, only if CABLN = 0.
Z(15)	FFB	-	Lower limit for stability and to calculate Δt, only if CABLN = 0.
Z(16)	TMDZ	grams	Total (.) mass (t = 0) calculated in TCLAM.
Z(17)	TMXZ	grams	Total (X) mass (t = 0) calculated in TCLAM.
Z(18)	XMAX	cm	= X(iMAX).

Location	Symbol	Units	Description
Z(19)	TXMAX	cm	2 (XMAX) t = 0. calculated in TCLAM.
Z(20)	TYMAX	cm	2 (YMAX) t = 0. calculated in TCLAM.
Z(21)	AMDM	grams	Minimum (.) particle mass/2.; calculated in TCLAM.
Z(22)	AMXM	grams	Minimum (X) particle mass/2.; calculated in TCLAM.
Z(23)	DNN	-	$(ETH - E)^{n-NPC}/ETH$.
Z(24)	DMIN	-	IE (ECK). NOTE: Z(76) > DMIN, problem will stop and the EDIT routine will call dump.
Z(25)	FEF	-	~ .03 used in iteration routine for calculating pressures for partial volume.
Z(26)	DTNA	shake	Δt^{n-1}.
Z(27)	CVIS	-	If < 0, bottom boundary is transmittive; otherwise reflective boundary.
Z(28)	NPR	-	Index (working storage).
Z(29)	NPRi	-	Index (working storage).
Z(30)	NC	-	Cycle number in fixed point.
Z(31)	NPC	-	Number of cycles between short prints.
Z(32)	NRC	-	Index.
Z(33)	iMAX	-	Maximum number of zones in R direction.
Z(34)	iMAXA	-	iMAX + 1.
Z(35)	jMAX	-	Maximum number of zones in Z direction.
Z(36)	jMAXA	-	jMAX + 1.
Z(37)	kMAX	-	(iMAX)(jMAX) + 1.
Z(38)	kMAXA	-	kMAX + 1.
Z(39)	NMAX	-	Total number of particles + 1, generated in TCLAM for PIC problem only.

Location	Symbol	Units	Description
Z(40)	ND	-	Total number of (.) particles + 1 generated in TCLAM.
Z(41)	KDT	-	Defined previously.
Z(42)	IXMAX	-	Not used.
Z(43)	NOD	-	Index.
Z(44)	NOPR	-	Index.
Z(45)	NIMAX	-	New iMAX before adding new zones.
Z(46)	NJMAX	-	New jMAX before adding new zones.
Z(47)	I1	-	Defined previously.
Z(48)	I2	-	Defined previously.
Z(49)	I3	-	Not used.
Z(50)	I4	-	Not used.
Z(51)	N1	-	Maximum number of iterations allowed in ES calculation of a mixed cell.
Z(52)	N2	-	Not used.
Z(53)	N3	-	Not used.
Z(54)	N4	-	Not used.
Z(55)	N5	-	Not used.
Z(56)	N6	-	Not used.
Z(57)	N7	-	Not used.
Z(58)	N8	-	Not used.
Z(59)	N9	-	Not used.
Z(60)	N10	-	= i value of zone that is controlling Δt.
Z(61)	N11	-	= j value of zone that is controlling Δt.
Z(62)	NRM	-	= maximum number of radiation cycles/hydro (input number).

Location	Symbol	Units	Description
Z(63)	TRAD	shake	NR · Δt radiation = Δt hydro; not used in this version.
Z(64)	XNRG	-	Not used.
Z(65)	SN	-	Not used.
Z(66)	DXN	-	Not used.
Z(67)	RADER	g-cm-shake	Total positive radial momentum (X only).
Z(68)	RADET	g-cm-shake	Total positive axial momentum (X only).
Z(69)	RADEB	-	Not used.
Z(70)	DTRAD	-	Not used.
Z(71)	REZFCT	-	If = 0, PH2 will not trigger REZONE.
Z(72)	RSTOP	-	Not used in continuous version.
Z(73)	SHELL	-	Not used.
Z(74)	BBOUND	-	Not used in this version.
Z(75)	TOZONE	g/cm^3	Minimum density for mass flow at free surface.
Z(76)	ECK	energy check	$\left[\left(\frac{ETH - E}{ETH}\right)^n - \left(\frac{ETH - E}{ETH}\right)^{n-NPC}\right] \Big/ NPC.$
Z(77)	SBOUND	-	Fraction of Δ in mass weighting velocity EUL PH2 $\sim$ 1.0.
Z(78)	X1	-	Not used.
Z(79)	X2	-	Not used.
Z(80)	Y1	-	Not used.
Z(81)	Y2	-	Not used.
Z(82)	CABLN	-	Already defined.
Z(83)	VISC	-	Not used.
Z(84)	T	shake	Total time up to cycle N, $t^n = t^{n-1} + \Delta t$.
Z(85)	GMAX	-	Maximum of γX or γ.

Location	Symbol	Units	Description
Z(86)	WSGD	-	γ.
Z(87)	WSGX	-	γX and (γMAX - 1) in CDT.
Z(88)	GMADR	-	γ./(γ. - 1).
Z(89)	GMAXR	-	γX/(γX - 1).
Z(90)	S1	-	Not used.
Z(91)	S2	-	Not used.
Z(92)	S3	-	Not used.
Z(93)	S4	-	Not used.
Z(94)	S5	-	Not used.
Z(95)	S6	-	Not used.
Z(96)	S7	-	Not used.
Z(97)	S8	-	Used in TCLAM only.
Z(98)	S9	-	Not used.
Z(99)	S10	-	Not used.
Z(100)		grams	Mass thrown away (PH2) continuous transport.
Z(101)		jerks	Total energy thrown away.
Z(102)		-	Not used.
Z(103)		-	Not used.
Z(104)		jerks	Energy (internal) added to system when internal is set to 0 if I < 0.
Z(105)		yes	Fraction of stability at early times.
Z(106)		yes	(1. + %) increase/cycle until Z(106) = Z(139).
Z(107)		yes	X mass cut off in PH2.
Z(108)		yes	. mass cut off in PH2.
Z(109)		-	Not used.

Location	Symbol	Units	Description
Z(110)		-	Not used.
Z(111)		g/cm^3	Initial density of material.
Z(112)		cm-shake	Initial velocity of pellet.
Z(113)		-	Epsilonics for emptying pellet $\approx$ .01.
Z(114)		-	Not used.
Z(115)	ρ_X		
Z(116)	$\rho_\bullet$		
Z(117)	a_X		
Z(118)	$a_\bullet$		
Z(119)	E^X		
Z(120)	$E^\bullet$		
Z(121)	b_X		
Z(122)	$b_\bullet$		
Z(123)	A_X		For equation of state constants. Are the same as in OIL report GAMD-5580.
Z(124)	$A_\bullet$		
Z(125)	V_s^X		
Z(126)	$V_s^\bullet$		
Z(127)	E_s^X		
Z(128)	$E_s^\bullet$		
Z(129)	α^X		
Z(130)	$\alpha^\bullet$		
Z(131)	β^X		
Z(132)	$\beta^\bullet$		
Z(133)	B^X		
Z(134)	$B^\bullet$		

Location	Symbol	Units	Description
Z(135)		-	Not used.
Z(136)		-	Not used.
Z(137)		-	Not used.
Z(138)		g/cm^3	Density check if $\rho(K) < Z(138)$ stability check for cell (K) is bypassed.
Z(139)		-	Percent of instability, used in CDT if CABLN $< 0 \approx .5$.
Z(140)		-	Not used.
Z(141)		-	Not used.
Z(142)		-	Not used.
Z(143)		g/cm^3	Minimum (.) density in PH2 $\sim 10^{-3}\ \rho_o'$.
Z(144)		g/cm^3	Minimum (X) density in PH2 $\sim 10^{-3}\ \rho_x'$.
Z(145)		jerk/g	ϵ on I in PH1, PH2 $\sim 10^{-9}$.
Z(146)		cm-shake	ϵ on U or V in PH1, PH2 $\sim 10^{-6}$.
Z(147)		-	j (of pellet-target interface) at t = 0.
Z(148)	A	10^5 cm-sec	C (speed of sound = $A + BP^{\epsilon}$ where $A = C_o$ and P is in megabars.
Z(149)	B	-	
Z(150)	ϵ	-	

E. TCLAM AND TOIL LISTINGS

```
C        NOTE,THE FOLLOWING SET OF DIMENSION,
C        COMMON AND EQUIVALENCE ARE TO BE USED FOR ALL SUBROUTINES
C        ***** TCLAM ******
C          D    I    M    E    N    S    I    O    N                    INPU0020
C                                                                       INPU0030
         DIMENSION  AIX(5000), AID(5000),AM(130),
        1AMX(5000),AMD(5000),DX(100),ENDD(2),ITAB(502),
        2IZ(100),RONE(2),TAB(502),TABI(20),TABIY(21),TABR(20),
        3TABUV(20),TABX(21),TABY(21),TAU(100),TEMP(13),
        4U(5000),V(5000),X(100),XL(130),
        5YL(130),Z(150),Y(100),DY(100)                                  INPU0100
         DIMENSION IW1(130),IW2(130)
         COMMON Z,X,TAB,Y
         COMMON         AID      ,AIMAX   ,AIX     ,AJMAX   ,AM      ,AMD      INPU0120
         COMMON         AMX      ,DX      ,ENDD    ,FMX     ,GXN     ,GXX      INPU0130
         COMMON         GYN      ,GYX     ,I       ,IA      ,IB      ,IBA      INPU0140
         COMMON         IBB      ,ID      ,IG      ,II      ,IIC     ,IJ       INPU0150
         COMMON         IR       ,IRC     ,IUV     ,IUVC    ,IWS     ,IWSA     INPU0160
         COMMON         IWSB     ,IX      ,IXN     ,IXX     ,IYN     ,IYX      INPU0170
         COMMON         J        ,JA      ,JT      ,JTM     ,K       ,KE       INPU0180
         COMMON         KF       ,KK      ,L       ,LA      ,LB      ,LD       INPU0190
         COMMON         LE       ,LI      ,LX      ,M       ,MI      ,MIJ      INPU0200
         COMMON         MJ       ,MN      ,MNP     ,MX      ,MXA     ,MXS      INPU0210
         COMMON         MZ       ,NPKG    ,NPP     ,NT      ,NX      ,NY       INPU0220
         COMMON         Q100FL,RHO        ,RONE,SLA,SLB       ,TABI              INPU0230
         COMMON         TABIY    ,TABR    ,TABUV   ,TABX    ,TABY    ,TAM      INPU0240
         COMMON         TAU      ,TEMP    ,TFMX    ,TPIDY   ,TX      ,TY       INPU0250
         COMMON         U        ,V       ,WPIDY   ,WS      ,WSA     ,WSB      INPU0260
         COMMON         WSC      ,WSD     ,WSE     ,WSF     ,WSG     ,WSI      INPU0270
         COMMON         WSL      ,WSU     ,WSV     ,WSX     ,WSY     ,WS5      INPU0280
         COMMON         XC       ,XL      ,YC      ,YL      ,YMAX    ,WSR      INPU0290
         COMMON         PE       ,PM      ,TTX     ,TTY     ,LF      ,E        INPU0300
         COMMON         PEE      ,NPRR    ,NYY     ,DY      ,NK      ,SWITCH   INPU0310
         COMMON         IW1      ,IW2                                          INPU0320
                                                                               INPU0400
C                                                                              INPU0410
C             E    Q    U    I    V    A    L    E    N    C    E              INPU0420
C                                                                              INPU0430
         0EQUIVALENCE     (Z,IZ,PROB),       (Z(2),CYCLE),      (Z(3),DT),        INPU0430
         1(Z(4),PRINTS),  (Z(5),PRINTL),     (Z(6),DUMPT7),     (Z(7),CSTOP),     INPU0440
         2(Z(8),PIDY),    (Z(9),TMZ),        (Z(10),GAM),       (Z(11),GAMD),     INPU0450
         3(Z(12),GAMX),   (Z(13),ETH),       (Z(14),FFA),       (Z(15),FFB),      INPU0460
         4(Z(16),TMDZ),   (Z(17),TMXZ),      (Z(18),XMAX),      (Z(19),TXMAX),    INPU0470
         5(Z(20),TYMAX),  (Z(21),AMDM),      (Z(22),AMXM),      (Z(23),DNN),      INPU0480
         6(Z(24),DMIN),   (Z(25),FEF),       (Z(26),DTNA),      (Z(27),CVIS),     INPU0490
         7(Z(28),NPR),    (Z(29),NPRI),      (Z(30),NC),        (Z(31),NPC),      INPU0500
         8(Z(32),NRC),    (Z(33),IMAX),      (Z(34),IMAXA),     (Z(35),JMAX),     INPU0510
         9(Z(36),JMAXA),  (Z(37),KMAX),      (Z(38),KMAXA),     (Z(39),NMAX)      INPU0520
         0EQUIVALENCE     (Z(40),ND),        (Z(41),KDT),       (Z(42),IXMAX),    INPU0530
         1(Z(43),NOD),    (Z(44),NOPR),      (Z(45),NIMAX),     (Z(46),NJMAX),    INPU0540
         2(Z(47),I1),     (Z(48),I2),        (Z(49),I3),        (Z(50),I4),       INPU0550
         3(Z(51),N1),     (Z(52),N2),        (Z(53),N3),        (Z(54),N4),       INPU0560
         4(Z(55),N5),     (Z(56),N6),        (Z(57),N7),        (Z(58),N8),       INPU0570
         5(Z(59),N9),     (Z(60),N10),       (Z(61),N11),       (Z(62),NRM),      INPU0580
         6(Z(63),TRAD),   (Z(64),XNRG),      (Z(65),SN),        (Z(66),DXN),      INPU059
         7(Z(67),RADER),  (Z(68),RADET),     (Z(69),RADEB),     (Z(70),DTRAD),    INPU060
         8(Z(71),REZFCT), (Z(72),RSTOP),     (Z(73),SHELL),     (Z(74),BBOUND),INPU061
         9(Z(75),TOZONE), (Z(76),ECK),       (Z(77),SBOUND),    (Z(78),X1)        INPU062
         0EQUIVALENCE     (Z(79),X2),        (Z(80),Y1),        (Z(81),Y2),       INPU063
```

```
     1(Z(82),CABLN),    (Z(83),VISC),      (Z(84),T),         (Z(85),GMAX),   INPU0640
     2(Z(86),WSGD),     (Z(87),WSGX),      (Z(88),GMADR),     (Z(89),GMAXR),  INPU0650
     3(Z(90),S1),       (Z(91),S2),        (Z(92),S3),        (Z(93),S4),     INPU0660
     4(Z(94),S5),       (Z(95),S6),        (Z(96),S7),        (Z(97),S8),     INPU0670
     5(Z(98),S9),       (Z(99),S10)                                           INPU0680
      EQUIVALENCE (Z,IZ),(TAB,ITAB)
      DIMENSION PLOT(10)
      DATA PLOT/3H X ,3HDOT,3HGEN,3HDEL/
CMAIN                                                                         MAIN0010
C L A M                 ******   M A I N   ******                           MAIN0020
C                                                                             MAIN0030
C                                                                             MAIN0050
      CALL SLITE (0)                                                          MAIN0060
C     INPUT ROUTINE CALCULATES THE ACTUAL GRID,
C     DIMENSIONS AND INDICES.
   10 CALL INPUT                                                              MAIN0070
C     PH1, READS IN DATA CARDS FOR THE
C     PACKAGES, PH2 CALCULATES THE GEOMETRICS,
C     PH3 THE PARTICLES, PH4 CALLS THE
C     6 POSSIBLE FITS THAT CALCULATE THE
C     DENSITY, VELOCITIES AND INTERNAL ENERGY
C     OF THE PARTICLES.
   20 CALL PH1                                                                MAIN0080
C     OUTPUT CALCULATES THE VELOCITY (BOTH
C     RADIAL AND AXIAL) AND SPECIFIC INTERNAL
C     ENERGY OF EACH CELL FROM THE
C     TOTAL MOMENTA AND INTERNAL
C     ENERGY AND MASS OF EACH CELL.
C     OUTPUT ALSO PREPARES A DUMP TAPE
C      WHICH IS USED THEN TO START TOIL
   30 CALL OUTPUT                                                             MAIN0090
      CALL EXIT                                                               MAIN0100
      END                                                                     MAIN0110
      SUBROUTINE INPUT                                                        INPU0010
C                                                                             INPU0710
C
C     ******* A 2 MATERIAL CLAM FOR THE TOIL CODE *************
C
C                                                                             INPU0730
C                                                                             INPU0940
      MZ=150                                                                  INPU0960
C     CLEAR Z BLOCK.
      DO 30 I=1,MZ                                                            INPU0970
   30 Z(I)=0.0                                                                INPU0980
C                READ IN HEADING CARD                                         INPU0990
      READ  (5,8012)IWS                                                       INPU1000
      IWS=1                                                                   INPU1010
      WRITE (6,8012)(IWS)                                                     INPU1020
      WRITE (6,8100)                                                          INPU1030
C                READ IN PROBLEM CONSTANTS                                    INPU1040
C     PROB=PROBLEM NO. AIMAX=IMAX,
C     AJMAX=JMAX, Q000FL IS NOT USED-SET
C     TO ZERO, SHELL SET=2.,S8,S9 ARE
C     ZERO, SET N7 TO=TAPE NO.
      READ  (5,8004)PROB,AIMAX,AJMAX,Q000FL,SHELL,S8,S9,N7                    INPU1050
      IF(N7)40,40,50                                                          INPU1060
   40 N7=9
```

```
   50 CONTINUE
C     MAX. NUMBER OF ZONES IN R DIRECTION.
      MI=100
C     MAX. NUMBER OF ZONES IN Z DIRECTION.
      MJ=100
C     MAX. NUMBER OF PARTICLES/CELL.
      MNP=400
C                  SIZE OF TABLE (TAB)
      JTM=500
C                  MAXIMUM  I*J
C     MAX. NUMBER OF CELLS.
   60 MIJ=4999
C        CALCULATE ADDITIONAL INDICES FOR TCLAM
C        AND TOIL.
   70 IMAX=AIMAX
      JMAX=AJMAX
      IMAXA=IMAX+1
      IXMAX=IMAXA+1
      JMAXA=JMAX+1
      KMAX=(IMAX*JMAX)+1
      KMAXA=KMAX+1
      WRITE (6,8048)(PROB,IMAX,JMAX)
C     CHECK INPUT NOS. CONCERNED WITH GRID SIZE.
  101 IF(IMAX-MI)102,102,9901
  102 IF(JMAX-MJ)104,104,9902
  104 IF(KMAX-MIJ-1)106,106,9903
  106 NOD=1
      NPC=1
      NRC=0
C                  READ IN DY AND DX
      I=0
      J=0
      X(I)=0.0
      Y(J)=0.0
 2000 READ  (5,8102)IWSA,IWSB,N1,N2,N3,N4,(TEMP(K),K=1,4)
      L=1
C     COUNT NO. OF DIFFERENT DX OR DY.
      IF(N4)2003,2001,2003
 2001 IF(N3)2004,2002,2004
 2002 IF(N2)2006,2008,2006
 2003 L=L+1
 2004 L=L+1
 2006 L=L+1
 2008 IF(IWSB)2010,2010,2030
C     PROCESS THE DX AND DY VALUES.
 2010 DO 2014 N=1,L
      NK=IZ(N+50)
      DO 2012 K=1,NK
      I=I+1
      DX(I)=TEMP(N)
      X(I)=X(I-1)+DX(I)
 2012 CONTINUE
 2014 CONTINUE
      GO TO 2050
C     CALC THE  Y  AND  DY  VALUES
 2030 DO 2034 N=1,L
      NK=IZ(N+50)
```

```
      DO 2032 K=1,NK
      J=J+1
      DY(J)=TEMP(N)
      Y(J)=Y(J-1)+DY(J)
 2032 CONTINUE
 2034 CONTINUE
 2050 IF(IWSA)2052,2000,2052
C     IF(=) READ MORE DX OR DY DATA CARDS.
 2052 IF(J-JMAX)9905,2053,9905
C     CHECK INPUT NUMBERS.
 2053 IF(I-IMAX)9906,2054,9906
 2054 CONTINUE
      READ  (5,8004)WS,WSA,WSB,SWITCH
C     N4=MAX. NUMBER OF PARTICLES-1 PER RECORD.
      N4=WSB
      NPRI=N4
      NPRR=N4
      WRITE (6,8064)IMAX,(X(I),I=0,IMAX)
      WRITE (6,8065)JMAX,(Y(J),J=0,JMAX)
      WS=3.1415927
      WSA=0.0
C     CALCULATE THE AREA-S(TAU)=PI(R(I)**2-
C     R(I-1)**2).
      DO 1008 I=1,IMAX
      WSB=WSA
      WSA=X(I)**2
 1008 TAU(I)=WS*(WSA-WSB)
C     WRITE OUT X,Y,DX,DY, AND TAU VALUES.
      WRITE (6,8066)IMAX,(DX(I),I=1,IMAX)
      WRITE (6,8067)JMAX,(DY(I),I=1,JMAX)
      WRITE (6,8092)(IMAX,(TAU(I),I=1,IMAX))
 1010 XMAX=X(IMAX)
      TXMAX=XMAX*2.0
      YMAX=Y(JMAX)
      TYMAX=YMAX*2.0
C     PIDY IS REALLY PI(3.1415927).
      PIDY=WS
C     SET VELOCITIES, INTERNAL ENERGIES AND MASSES
C     TO 0.
      DO 1014 I=1,KMAXA
      U(I)=0.0
      V(I)=0.0
      AIX(I)=0.0
      AMX(I)=0.0
      AID(I)=0.
      AMD(I)=0.
 1014 CONTINUE
C     SET TOTAL ENERGY TO ZERO.
      ETH=0.0
C     INITIALIZE MIN. MASS PARTICLE TO A LARGE NO.
      AMDM=1.E+28
      AMXM=AMDM
      GO TO 2016
C                ERROR
C      YOU HAVE IMAX GREATER THAN 100
 9901 NK=101
      GO TO 9999
```

```
C       YOU HAVE JMAX GREATER THAN 100
 9902 NK=102                                                            INPU2040
      GO TO 9999                                                        INPU2050
C       YOU HAVE TRIED TO GENERATE MORE THAN
C       4999 CELLS.
 9903 NK=104                                                            INPU2060
      GO TO 9999                                                        INPU2070
C                 JMAX DOES NOT EQUAL THE SUM OF THE INPUT J            INPU2080
 9905 NK=2052                                                           INPU2090
      GO TO 9999                                                        INPU2100
C                 IMAX DOES NOT EQUAL THE SUM OF THE INPUT I            INPU2110
 9906 NK=2053                                                           INPU2120
 9999 WRITE (6,8888)NK,I,J,K,L,M,N                                      INPU2130
      PRINT 8888,NK,I,J,K,L,M,N                                         INPU2140
      CALL DUMP                                                         INPU2150
 2016 RETURN                                                            INPU2160
C                 FORMATS                                               INPU2170

 8004 FORMAT(7E10.5,I2)                                                 INPU2180
 80120FORMAT (I1,71HTHIS IS THE CLAM PROGRAM AND THERE IS AN ERROR.     INPU2190
    1                 )                                                 INPU2200
 8048 FORMAT(1H /9H PROB NO.F9.3,12X,2HI=I2,26X,2HJ=I2)                 INPU2210
 8064 FORMAT(1H /10H X(I) I=0,I2/(5F16.6))                              INPU2220
 8065 FORMAT(1H /10H Y(J) J=0,I2/(5F16.6))                              INPU2230
 8066 FORMAT(1H /11H DX(I) I=1,I2/(5F16.6))                             INPU2240
 8067 FORMAT(1H /11H DY(J) J=1,I2/(5F16.6))                             INPU2250
 8092 FORMAT(1H /13H AREA(I) I=1,I2/(5F16.6))                           INPU2260
 8100 FORMAT(1H /14H (TOIL  INPUT))
 8102 FORMAT(2I1,4I2,4E10.4)                                            INPU2280
 8888 FORMAT(1H+/26H1 INPUT ERROR IN STATEMENTI5,12X,12H INDICES ARE6I7)INPU2290
      END                                                               INPU2300
      SUBROUTINE PH1                                                    PH1 0010
C                                                                       INPU0710
C
C     ******* A 2 MATERIAL CLAM FOR THE TOIL CODE *************
C
C                 READ IN GEOMETRY ETC.                                 PH1 0960
      NPP=7                                                             PH1 0980
      NPR=NPP-1                                                         PH1 0990
      TPIDY=PIDY*2.0                                                    PH1 1000
      ND=0                                                              PH1 1010
      NX=0                                                              PH1 1020
      NT=1                                                              PH1 1030
      NYY=1                                                             PH1 1040
C     FIRST CARD OF EACH PACKAGE.
      READ  (5,8008)IX,LX,MX,TEMP(1),TEMP(2),TEMP(3)                    PH1 1050
C     INITIALIZE THE NUMBER OF PACKAGES TO 0.
      NPKG=0                                                            PH1 1060
 2015 IF(IX-1)9901,2018,2018                                            PH1 1070
 2016 IX=I                                                              PH1 1080
      LX=L                                                              PH1 1090
      MX=M                                                              PH1 1100
C                 IF THERE ARE NO MORE PACKAGES GO COMPUTE TOTAL VALUES PH1 1110
C     THE LAST CARD HAS A 2 PUNCH IN COL 1.
 2017 IF(IX-2)2018,7000,9902                                            PH1 1120
 2018 J=0                                                               PH1 1130
      NPKG=NPKG+1                                                       PH1 1140
```

```
C       SET PACKAGE MASS AND ENERGY TO 0.
        PE=0.0
        PM=0.0
C       ORIGIN FOR THE RADIUS VECTORS TO BE USED
C       FOR THE FIT ROUTINES(1 THRU 6).
        YC=TEMP(1)
        XC=TEMP(2)
C       S8 CONTAINS THE FIT NUMBER FOR THE
C       PACKAGE IN QUESTION.
        S8=TEMP(3)
        WRITE (6,8100)(NPKG,MX)
C       NOW READ IN THE GEOMETRY AND DENSITY,
C       ENERGY AND VELOCITY CARDS.
 2020   READ  (5,8008)I,L,M,(TEMP(N),N=1,6)
        IWS=1
        IF(I-5)2021,2040,2022
C       IF=, THIS IS A RHO, VELOCITY OR ENERGY CARD.
C       IF LESS, YOU HAVE READ ALL CARDS FOR THIS
C       PACKAGE IN, PLUS THE FIRST CARD FROM THE
C       NEXT PACKAGE.
 2021   IF(I-3)2060,9903,2026
C       IF GREATER, EITHER A TRIANGLE OR PERTURBED ELLIPSE.
 2022   IF(L)9904,2030,2024
C       A PERTURBED ELLIPSE.
 2024   IWS=7
        GO TO 2030
 2026   IWS=3
 2027   IF(L)9905,2030,2028
 2028   IWS=5
C       A TRIANGLE.
 2030   IF(M)9906,2034,2032
C       IF=, DELETE THIS GEOMETRY.
 2032   IWS=IWS+1
 2034   J=J+1
C       TAB STORAGE CONTAINS THE COORDINATES OF
C       GEOMETRY.
        ITAB(J)=IWS
        DO 2036 N=1,NPR
        J=J+1
 2036   TAB(J)=TEMP(N)
        GO TO 2020
C                   ONE ONLY RHO,I,U OR V ALLOWED PER PACKAGE
C       IF=, THIS IS A DENSITY CARD.
 2040   IF(L-1)9907,2046,2042
C       IF GREATER, EITHER A VELOCITY OR ENERGY CARD.
 2042   IF(L-3)2052,2058,9908
C       IF=, THIS IS A VELOCITY CARD, IF LESS, THIS IS A
C       ENERGY CARD.
C                   DENSITY
 2046   DO 2048 N=1,6
 2048   TABR(N)=TEMP(N)
        GO TO 2020
C                   ENERGY
 2052   DO 2054 N=1,6
 2054   TABI(N)=TEMP(N)
        GO TO 2020
C                   VELOCITY (U AND V)
```

```
 2058 DO 2059 N=1,6
.2059 TABUV(N)=TEMP(N)
      GO TO 2020
C              OUTPUT DENSITY, ENERGY, AND VELOCITY PARAMETERS
C     ALL CARDS FOR THIS PACKAGE HAVE
C     BEEN READ IN.
 2060 IF(J-JTM)2070,2070,9915
 2070 WRITE (6,8036)(TABR(II),II=1,6)
      WRITE (6,8038)(TABI(II),II=1,6)
      WRITE (6,8040)(TABUV(II),II=1,6)
C              COMPUTE BOUNDARIES OF GEOMETRIES FOR EFFICIENCY IN
C              GENERATING OR DELETING PARTICLES
 3000 CALL PH2
C              COMPUTE I(0),I(N),J(0) AND J(N),FROM PREVIOUSLY
C              COMPUTED VALUES,FOR UPPER AND LOWER LIMITS IN
C              THE CELL MESH SCAN
C     IXN=MINIMUM (I) OF GEOMETRY OF PACKAGE
C     IYN=MINIMUM (J) OF GEOMETRY OF PACKAGE
C     IXX=MAXIMUM (I) OF GEOMETRY OF PACKAGE
C     IYX=MAXIMUM (J) OF GEOMETRY OF PACKAGE
 3001 IXN=1
      IXX=1
      IWS=IMAX-1
 3800 IF(IWS)9929,3820,3801
 3801 DO 3808 N=1,IWS
      IF(X(N)-GXN)3802,3804,3804
 3802 IXN=IXN+1
 3804 IF(X(N)-GXX)3806,3806,3808
 3806 IXX=IXX+1
 3808 CONTINUE
      IF(IXN)3812,3812,3814
 3812 IXN=1
 3814 IF(IMAX-IXX)3816,3818,3818
 3816 IXX=IMAX
 3818 IF(IXN-IXX)3820,3820,9930
 3820 IYN=1
      IYX=1
      IWS=JMAX-1
 3821 IF(IWS)9929,3834,3822
 3822 DO 3813 N=1,IWS
 3823 IF(Y(N)-GYN)3819,3817,3817
 3819 IYN=IYN+1
 3817 IF(Y(N)-GYX)3815,3815,3813
 3815 IYX=IYX+1
 3813 CONTINUE
      IF(IYN)3824,3824,3826
 3824 IYN=1
 3826 IF(JMAX-IYX)3828,3830,3830
 3828 IYX=JMAX
 3830 IF(IYN-IYX)3834,3834,9931
 3834 WRITE (6,8044)IXN,IYN,IXX,IYX
C              SCAN CELL MESH TO DETERMINE IF PARTICLES ARE TO BE
C              GENERATED OR DELETED
C              GENERATE PARTICLES
 4000 CALL PH3
C              REARRANGE X,Y AND M FOR PARTICLES IF NECESSARY
 6011 LA=NY-NT
```

```
      IF(LX)9947,6020,6022                                              PH1 2020
 6020 ND=ND+LA                                                          PH1 2030
      GO TO 6024                                                        PH1 2040
 6022 NX=NX+LA                                                          PH1 2050
 6024 NT=NY                                                             PH1 2060
      ETH=ETH+PE                                                        PH1 2070
      WS=PLOT(1)
 6026 IF(LX)9933,6028,6030                                              PH1 2100
 6028 WS=PLOT(2)
 6030 WRITE (6,8501)LA,WS,PE,PM                                         PH1 2130
C                   GO READ IN NEXT PACKAGE                             PH1 2140
 6050 GO TO 2016                                                        PH1 2150
 7000 NMAX=NT                                                           PH1 2160
C     NMAX=MAX. NUMBER OF PARTICLES+1.
C     YOU HAVE PROCESSED ALL PACKAGES, ALL
C     PARTICLES, NOW GO TO THE OUTPUT.
      IF(AM(2))4051,4050,4051                                           PH1 2170
 4050 N3=NRC                                                            PH1 2180
      GO TO 4060                                                        PH1 2190
 4051 NRC=NRC+1                                                         PH1 2200
      N3=NRC                                                            PH1 2210
C     N3=NO. OF PARTICLE RECORDS OF
C     N4 WORDS.
 4060 N6=NMAX-(N4-1)*(N3-1)                                             PH1 2240
      NOPR=N3                                                           PH1 2250
      GO TO 10000                                                       PH1 2270
C                   ERROR                                               PH1 2280
 9901 NK=2015                                                           PH1 2290
      GO TO 9999                                                        PH1 2300
 9902 NK=2017                                                           PH1 2310
      GO TO 9999                                                        PH1 2320
 9903 NK=2021                                                           PH1 2330
      GO TO 9999                                                        PH1 2340
 9904 NK=2022                                                           PH1 2350
      GO TO 9999                                                        PH1 2360
 9905 NK=2027                                                           PH1 2370
      GO TO 9999                                                        PH1 2380
 9906 NK=2030                                                           PH1 2390
      GO TO 9999                                                        PH1 2400
 9907 NK=2040                                                           PH1 2410
      GO TO 9999                                                        PH1 2420
 9908 NK=2042                                                           PH1 2430
      GO TO 9999                                                        PH1 2440
 9915 NK=2060                                                           PH1 2450
      GO TO 9999                                                        PH1 2460
 9929 NK=3800                                                           PH1 2470
      GO TO 9999                                                        PH1 2480
 9930 NK=3818                                                           PH1 2490
      GO TO 9999                                                        PH1 2500
 9931 NK=3830                                                           PH1 2510
      GO TO 9999                                                        PH1 2520
 9933 NK=6026                                                           PH1 2530
      GO TO 9999                                                        PH1 2540
 9947 NK=6011                                                           PH1 2550
 9999 WRITE (6,8888)NK                                                  PH1 2560
      PRINT 8888,NK                                                     PH1 2570
      CALL DUMP                                                         PH1 2580
```

```
10000 RETURN                                                            PH1 2590
C                    FORMATS                                            PH1 2600
 8008 FORMAT (2I1,I5,E13.5,5E10.5)                                      PH1 2610
 8036 FORMAT(1H07X,8HDENSITY 9X,1P6E16.6)                               PH1 2620
 8038 FORMAT(1H07X,8HENERGY  9X,1P6E16.6)                               PH1 2630
 8040 FORMAT(1H07X,8HVELOCITY9X,1P6E16.6/1H0/)                          PH1 2640
 8044 FORMAT(1H /6H I(1)=I2,4X,5HJ(1)=I2,4X,5HI(N)=I2,4X,5HJ(N)=I2)     PH1 2650
 81000FORMAT(1H0///12H0PACKAGE NO.I3,I20,15H PARTICLES/CELL//33X,2HA114XPH1 2660
     1,2HA214X,2HA314X,2HA414X,2HA514X,2HA6)                            PH1 2670
 85010FORMAT(1H0/I28,2H (A3,11H) PARTICLES22X,4HPE =1PE12.6,16X,4HPM =E1PH1 2680
     12.6)                                                              PH1 2690
 8888 FORMAT(23H1PH1 ERROR IN STATEMENTI5)                              PH1 2700
      END                                                               PH1 2710
      SUBROUTINE PH2                                                    PH2 0010
C
C     ******* A 2 MATERIAL CLAM FOR THE TOIL CODE *************
C
CALCULATE THE PACKAGE GEOMETRIES                                        PH2 0020
C                                                                       PH2 0740
C                                                                       PH2 0950
C                                                                       PH2 0960
C                    GENERATING OR DELETING PARTICLES                   PH2 0970
C     J=VALUE OF LAST COORDINATE READ IN.
      JT=J                                                              PH2 0980
C     INITIALIZE OUTER BOUNDARIES.
      GXN=XMAX                                                          PH2 0990
      GYN=YMAX                                                          PH2 1000
      GXX=0.0                                                           PH2 1010
      GYX=0.0                                                           PH2 1020
C     NPP=7(SET IN PH1).
      DO 3700 J=1,JT,NPP                                                PH2 1030
C     IWS STORED IN ITAB ARRAY IN PH1.
C     IF IWS=2(A TRIANGLE),IF=4(A RECTANGLE),
C     IF=6,A ELLIPSE OR CIRCLE. IF IWS=8,A
C     PERTURBED ELLIPSE. IF IWS IS LESS THAN
C     THESE VALUES, THE DEFINITION STILL HOLDS, BUT
C     NOW DELETE THIS GEOMETRY.
      KK=(ITAB(J)-1)/2                                                  PH2 1040
 3007 IF(KK)9919,3010,3008                                              PH2 1050
 3008 IF(KK-2)3100,3200,3009                                            PH2 1060
 3009 IF(KK-4)3400,9920,9920                                            PH2 1070
C                    TRIANGLE                                           PH2 1080
C     VERTICES CAN BE INPUTED IN ANY ORDER,
C     X COORDINATE FIRST.
C     SEARCH FOR THE LARGEST X(WSE) AND
C     SMALLEST X(WSD).
C     FIND MAXIMUM(WSE) AND MINIMUM(WSD) X COORDINATE                   PH2 1090
 3010 IF(TAB(J+1)-TAB(J+3))3011,3012,3013                               PH2 1100
 3011 WSE=TAB(J+3)                                                      PH2 1110
      WSD=TAB(J+1)                                                      PH2 1120
      GO TO 3014                                                        PH2 1130
 3012 TAB(J+1)=TAB(J+1)*1.0000001+1.0E-8                                PH2 1140
 3013 WSE=TAB(J+1)                                                      PH2 1150
      WSD=TAB(J+3)                                                      PH2 1160
 3014 IF(TAB(J+5)-WSD)3020,3019,3016                                    PH2 1170
 3016 IF(TAB(J+5)-WSE)3024,3017,3018                                    PH2 1180
 3017 TAB(J+5)=TAB(J+5)*1.0000001+1.0E-8                                PH2 1190
```

```
 3018 WSE=TAB(J+5)                                                  PH2 1200
      GO TO 3024                                                    PH2 1210
 3019 TAB(J+5)=TAB(J+5)*0.9999999-1.0E-8                            PH2 1220
 3020 WSD=TAB(J+5)                                                  PH2 1230
C                    ARRANGE VERTICES IN ASCENDING ORDER            PH2 1240
 3024 IF(TAB(J+2)-TAB(J+4))3036,3034,3038                           PH2 1250
 3034 TAB(J+2)=TAB(J+2)*1.0000001+1.0E-8                            PH2 1260
      GO TO 3038                                                    PH2 1270
 3036 WSA=TAB(J+1)                                                  PH2 1280
      WSB=TAB(J+2)                                                  PH2 1290
      TAB(J+1)=TAB(J+3)                                             PH2 1300
      TAB(J+2)=TAB(J+4)                                             PH2 1310
      TAB(J+3)=WSA                                                  PH2 1320
      TAB(J+4)=WSB                                                  PH2 1330
 3038 IF(TAB(J+4)-TAB(J+6))3042,3040,3044                           PH2 1340
 3040 TAB(J+6)=TAB(J+6)*0.9999999-1.0E-8                            PH2 1350
      GO TO 3044                                                    PH2 1360
 3042 WSA=TAB(J+3)                                                  PH2 1370
      WSB=TAB(J+4)                                                  PH2 1380
      TAB(J+3)=TAB(J+5)                                             PH2 1390
      TAB(J+4)=TAB(J+6)                                             PH2 1400
      TAB(J+5)=WSA                                                  PH2 1410
      TAB(J+6)=WSB                                                  PH2 1420
      GO TO 3024                                                    PH2 1430
C     WSF=MINIMUM VALUE OF Y
C     WSG=MAXIMUM VALUE OF Y
 3044 WSF=TAB(J+6)                                                  PH2 1440
      WSG=TAB(J+2)                                                  PH2 1450
C                    COMPUTE SLOPES                                 PH2 1460
      SLA=(TAB(J+4)-TAB(J+2))/(TAB(J+3)-TAB(J+1))                   PH2 1470
      SLB=(TAB(J+6)-TAB(J+2))/(TAB(J+5)-TAB(J+1))                   PH2 1480
 3053 IF(SLA-SLB)3054,9921,3058                                     PH2 1490
 3054 IF(SLA)3056,9922,3064                                         PH2 1500
 3056 IF(SLB)3064,9923,3062                                         PH2 1510
 3058 IF(SLA)3062,9924,3056                                         PH2 1520
 3062 WSA=TAB(J+3)                                                  PH2 1530
      WSB=TAB(J+4)                                                  PH2 1540
      WSC=SLA                                                       PH2 1550
      TAB(J+3)=TAB(J+5)                                             PH2 1560
      TAB(J+4)=TAB(J+6)                                             PH2 1570
      SLA=SLB                                                       PH2 1580
      TAB(J+5)=WSA                                                  PH2 1590
      TAB(J+6)=WSB                                                  PH2 1600
      SLB=WSC                                                       PH2 1610
 3064 IF(TAB(J+3)-TAB(J+5))3066,9925,3068                           PH2 1620
 3066 ITAB(J)=ITAB(J)+2                                             PH2 1630
      IWS=ITAB(J)-3                                                 PH2 1640
      GO TO 3069                                                    PH2 1650
 3068 IWS=ITAB(J)-1                                                 PH2 1660
 3069 KE=J+1                                                        PH2 1670
      KF=KE+5                                                       PH2 1680
      WS=PLOT(3)
      IF(IWS)3072,3070,3072                                         PH2 1710
 3070 WS=PLOT(4)
 3072 WRITE (6,8016)WS,(TAB(N),N=KE,KF)                             PH2 1740
      WS=TAB(J+2)-SLB*TAB(J+1)                                      PH2 1750
      TAB(J+1)=TAB(J+2)-SLA*TAB(J+1)                                PH2 1760
```

```
      TAB(J+6)=(TAB(J+6)-TAB(J+4))/(TAB(J+5)-TAB(J+3))                  PH2 1770
      TAB(J+5)=TAB(J+4)-TAB(J+6)*TAB(J+3)                               PH2 1780
      TAB(J+2)=SLA                                                      PH2 1790
      TAB(J+3)=WS                                                       PH2 1800
      TAB(J+4)=SLB                                                      PH2 1810
      GO TO 3600                                                        PH2 1820
C                     RECTANGLE                                         PH2 1830
 3100 ITAB(J)=ITAB(J)+2                                                 PH2 1840
      IWS=ITAB(J)-5                                                     PH2 1850
      WS=PLOT(3)
      IF(IWS)3110,3105,3110                                             PH2 1880
 3105 WS=PLOT(4)
 3110 WRITE (6,8020)WS,TAB(J+1),TAB(J+2),TAB(J+3),TAB(J+4)              PH2 1910
      WSD=TAB(J+1)                                                      PH2 1920
      WSE=TAB(J+2)                                                      PH2 1930
      WSF=TAB(J+3)                                                      PH2 1940
      WSG=TAB(J+4)                                                      PH2 1950
      GO TO 3600                                                        PH2 1960
C                     ELLIPSE OR CIRCLE                                 PH2 1970
 3200 IF(ABS(TAB(J+1)-TAB(J+2))-1.0E-8)3300,3300,3202                   PH2 1980
 3202 IF(TAB(J+2))9926,3300,3203                                        PH2 1990
C                     ELLIPSE WITH NO PERTURBATION                      PH2 2000
 3203 ITAB(J)=ITAB(J)+2                                                 PH2 2010
      IWS=ITAB(J)-7                                                     PH2 2020
      WS=PLOT(3)
      IF(IWS)3210,3205,3210                                             PH2 2050
 3205 WS=PLOT(4)
 3210 WRITE (6,8024)WS,TAB(J+1),TAB(J+2),TAB(J+3),TAB(J+4)              PH2 2080
 3215 WSD=TAB(J+3)-TAB(J+1)                                             PH2 2090
      WSE=TAB(J+3)+TAB(J+1)                                             PH2 2100
      WSF=TAB(J+4)-TAB(J+2)                                             PH2 2110
      WSG=TAB(J+4)+TAB(J+2)                                             PH2 2120
      TAB(J+1)=TAB(J+1)**2                                              PH2 2130
      TAB(J+2)=TAB(J+2)**2                                              PH2 2140
      GO TO 3600                                                        PH2 2150
C                     CIRCLE                                            PH2 2160
 3300 ITAB(J)=ITAB(J)+4                                                 PH2 2170
      IWS=ITAB(J)-9                                                     PH2 2180
      TAB(J+2)=TAB(J+1)                                                 PH2 2190
      WS=PLOT(3)
      IF(IWS)3310,3305,3310                                             PH2 2220
 3305 WS=PLOT(4)
 3310 WRITE (6,8028)WS,TAB(J+1),TAB(J+3),TAB(J+4)                       PH2 2250
      GO TO 3215                                                        PH2 2260
C                     ELLIPSE WITH PERTURBATION                         PH2 2270
 3400 ITAB(J)=ITAB(J)+4                                                 PH2 2280
      WS=1.0-(TAB(J+5)/TAB(J+1))**2                                     PH2 2290
      IWSA=ITAB(J+7)                                                    PH2 2300
     0TAB(J+7)=(TAB(J+6)-TAB(J+4)-TAB(J+2)*SQRT(WS))/                   PH2 2310
     1         ((TAB(J+5)*(TAB(J+5)-TAB(J+1)))**2)                      PH2 2320
      IWS=ITAB(J)-11                                                    PH2 2330
      KE=J+1                                                            PH2 2340
      KF=KE+6                                                           PH2 2350
      WSA=PLOT(3)
      IF(IWS)3410,3405,3410                                             PH2 2380
 3405 WSA=PLOT(4)
 3410 WRITE (6,8032)WSA,(TAB(N),N=KE,KF)                                PH2 2410
```

```
 3415 IF(WS)9927,9927,3420
 3420 IF(TAB(J+3))9928,3425,9928
 3425 TAB(J+3)=TAB(J+7)
      ITAB(J+7)=IWSA
      WSA=TAB(J+2)+TAB(J+2)/4.0
      WSD=0.0
      WSE=TAB(J+1)+TAB(J+1)/4.0
      WSF=TAB(J+4)-WSA
      WSG=TAB(J+4)+WSA
C                DETERMINE BOUNDARIES OF GEOMETRIES
 3600 IF(WSD-GXN)3602,3604,3604
C     MAXIMUM (X)
 3602 GXN=WSD
 3604 IF(WSE-GXX)3608,3608,3606
C     MINIMUM (X)
 3606 GXX=WSE
 3608 IF(WSF-GYN)3610,3612,3612
C     MAXIMUM (Y)
 3610 GYN=WSF
 3612 IF(WSG-GYX)3700,3700,3614
C     MINIMUM (Y)
 3614 GYX=WSG
 3700 CONTINUE
      J=JT
      GO TO 10000
C                E R R O R
 9919 NK=3007
      GO TO 9999
 9920 NK=3009
      GO TO 9999
 9921 NK=3053
      GO TO 9999
 9922 NK=3054
      GO TO 9999
 9923 NK=3056
      GO TO 9999
 9924 NK=3058
      GO TO 9999
 9925 NK=3064
      GO TO 9999
 9926 NK=3202
      GO TO 9999
 9927 NK=3415
      GO TO 9999
 9928 NK=3420
 9999 WRITE (6,8888)NK
      PRINT 8888,NK
      CALL DUMP
10000 RETURN
 8016 FORMAT(15H0TRIANGLE ---- A3,7H ------1P6E16.6)
 8020 FORMAT(15H0RECTANGLE --- A3,7H ------1P6E16.6)
 8024 FORMAT(15H0ELLIPSE ----- A3,7H ------1P6E16.6)
 8028 FORMAT(15H0CIRCLE ------ A3,7H ------1PE16.6,16X,4E16.6)
 8032 FORMAT(15H0P ELLIPSE --- A3,7H ------1P6E16.6)
 8888 FORMAT(23H1PH2 ERROR IN STATEMENTI5)
      END
      SUBROUTINE PH3
```

```
C                                                                        INPU0710
C
C     ******* A 2 MATERIAL CLAM FOR THE TOIL CODE *************
C
C
C                                                                        INPU0030
C     GENERATE (OR DELETE) THE PARTICLES                                 PH3 0020
C                                                                        PH3 0740
C                                                                        PH3 0950
C                                                                        PH3 0960
C                                                                        PH3 0970
C                 SCAN CELL MESH TO DETERMINE IF PARTICLES ARE TO BE     PH3 0980
C                 GENERATED OR DELETED                                   PH3 0990
C                 G E N E R A T E    P A R T I C L E S                   PH3 1000
C     SAVE CURRENT VALUES OF COUNTERS.
 4000 IA=I                                                               PH3 1010
      JA=J                                                               PH3 1020
      IJ=K                                                               PH3 1030
      JT=L                                                               PH3 1040
      IF(IX-1)9932,4010,9932                                             PH3 1050
 4010 IF(MX-MNP)4012,4012,9935                                           PH3 1060
C     IF GREATER, YOU TRIED TO GENERATE MORE THAN
C     400 PARTICLES / CELL.
 4012 WS=MX                                                              PH3 1070
      FMX=SQRT(WS)                                                       PH3 1080
      MXS=FMX+.5                                                         PH3 1090
 4011 IF(MXS*MXS-MX)9936,4013,9936                                       PH3 1100
C     IF(GREATER OR LESS) THE NO. OF PARTICLES / CELL
C     THAT YOU REQUESTED WAS NOT N SQ. WHERE
C     N IS FROM 1 TO 20.
 4013 MXA=1-MX                                                           PH3 1110
      TFMX=.5/FMX                                                        PH3 1120
      WPIDY=TPIDY/FMX                                                    PH3 1130
 4015 IF(MXA)4018,4018,9937                                              PH3 1140
C     IF GREATER, YOU HAVE FAILED TO SPECIFY THE
C     NO. OF PARTICLES TO GENERATE.
 4018 NY=NT                                                              PH3 1150
      DO 5700 I=IXN,IXX                                                  PH3 1160
C                 COMPUTE THE COORDINATE OF THE PARTICLE                 PH3 1170
C                 UNDER CONSIDERATION                                    PH3 1180
      WS5=DX(I)/FMX                                                      PH3 1190
C     THE VOLUME OF THE SUBDIVIDED CELL =
C     PI(2.*XL(N)DY/N*DY/N).
      TABX(1)=X(I)-TFMX*DX(I)                                            PH3 1200
 4019 IF(MXA)4020,4024,9938                                              PH3 1210
 4020 DO 4022 K=2,MXS                                                    PH3 1220
C     WE START AT THE RIGHT AND TOP OF CELL(K).
C     SET UP ARRAY FOR X COORDINATES OF THE
C     PARTICLES.
 4022 TABX(K)=TABX(K-1)-WS5                                              PH3 1230
C     J LOOP, LIMITS OF Y FOR THIS PACKAGE.
 4024 DO 5700 J=IYN,IYX                                                  PH3 1240
      TAM=WPIDY*WS5*DY(J)                                                PH3 1250
C     TAM= 2PI/N*DX/N*DY
      E=0.0                                                              PH3 1260
      IIWS=0                                                             PH3 1270
      IWS=0                                                              PH3 1280
```

```
      IB=0                                                              PH3 1290
      WS=DY(J)/FMX                                                      PH3 1300
      TABY(1)=Y(J)-TFMX*DY(J)                                           PH3 1310
C     MXS=N
      DO 4026 K=2,MXS                                                   PH3 1320
C     SET UP ARRAY FOR Y COORDINATES OF THE
C     PARTICLES.
 4026 TABY(K)=TABY(K-1)-WS                                              PH3 1330
C     K USED FOR THE CELL QUANTITIES.
      K=(J-1)*IMAX+I+1                                                  PH3 1340
 4028 IBB=IB/MXS                                                        PH3 1350
      IB=IB+1                                                           PH3 1360
      IBA=MOD(IB,MXS)                                                   PH3 1370
C     TX=X COORDINATE OF PARTICLE IN QUESTION.
      TX=TABX(IBA+1)                                                    PH3 1380
C     TY=Y COORDINATE OF PARTICLE IN QUESTION.
      TY=TABY(IBB+1)                                                    PH3 1390
C                 GENERATE OR DELETE THE PARTICLE                       PH3 1400
      ID=0                                                              PH3 1410
      IG=0                                                              PH3 1420
      L=1
 4202 CONTINUE
      KK=ITAB(L)                                                        PH3 1440
      IF(KK-5)4062,4073,4078                                            PH3 1450
C                 TRIANGLE                                              PH3 1460
 4062 WSX=(TY-TAB(L+1))/TAB(L+2)                                        PH3 1470
      IF(WSX-TX)4064,4064,4200                                          PH3 1480
 4064 WSX=(TY-TAB(L+3))/TAB(L+4)                                        PH3 1490
      IF(WSX-TX)4200,4066,4066                                          PH3 1500
 4066 WSY=TAB(L+6)*TX+TAB(L+5)                                          PH3 1510
      IF(KK-2)4068,4068,4072                                            PH3 1520
 4068 IF(WSY-TY)4200,4070,4070                                          PH3 1530
 4070 GO TO (4074,4076,4074,4076),KK                                    PH3 1540
 4072 IF(WSY-TY)4070,4070,4200                                          PH3 1550
 4074 ID=1                                                              PH3 1560
      GO TO 4200                                                        PH3 1570
 4076 IG=1                                                              PH3 1580
      GO TO 4200                                                        PH3 1590
 4078 KK=KK-4                                                           PH3 1600
 4077 IF(KK-8)4079,4094,9939                                            PH3 1610
 4079 GO TO (4080,4080,4090,4090,4092,4092,4094),KK                     PH3 1620
C                 RECTANGLE                                             PH3 1630
 4080 IF(TAB(L+1)-TX)4082,4082,4200                                     PH3 1640
 4082 IF(TAB(L+2)-TX)4200,4084,4084                                     PH3 1650
 4084 IF(TAB(L+3)-TY)4086,4086,4200                                     PH3 1660
 4086 IF(TAB(L+4)-TY)4200,4088,4088                                     PH3 1670
 4088 GO TO (4074,4076),KK                                              PH3 1680
C                 ELLIPSE WITH NO PERTURBATION                          PH3 1690
 4090 KK=KK-2                                                           PH3 1700
      IF((TX-TAB(L+3))**2/TAB(L+1)+(TY-TAB(L+4))**2                     PH3 1710
     1/TAB(L+2)-1.0)4088,4088,4200                                      PH3 1720
C                 CIRCLE                                                PH3 1730
 4092 KK=KK-4                                                           PH3 1740
     0IF((TX-TAB(L+3))**2+(TY-TAB(L+4))**2-TAB(L+1))                    PH3 1750
     1  4088,4088,4200                                                  PH3 1760
C                 ELLIPSE WITH PERTURBATION                             PH3 1770
 4094 KK=KK-6                                                           PH3 1780
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```
     0IF((TX/TAB(L+1))**2+(TY-TAB(L+4)-TAB(L+3)*(TX*                PH3 1790
     1  (TX-TAB(L+1)))**2)**2/TAB(L+2)-1.0)4088,4088,4200           PH3 1800
 4200 L=L+NPP
      IF(L-JA)4202,4201,4201
C                                                                   PH3 1820
C                IF ID=1 DELETE                                     PH3 1830
 4201 IF(ID)9940,4310,4800                                          PH3 1840
C                IF ID=0 AND IG=0 DELETE                            PH3 1850
 4310 IF(IG)9941,4800,4312                                          PH3 1860
C                GENERATE PARTICLE                                  PH3 1870
 4312 NY=NY+1                                                       PH3 1880
      IF(IIWS)23,22,23                                              PH3 1890
   22 IIWS=1                                                        PH3 1900
   23 IWS=1                                                         PH3 1910
      NYY=NYY+1                                                     PH3 1950
      CALL PH4
C     RETURN FROM PH4 WITH THE FOLLOWING DATA,
C     WSR=PARTICLE DENSITY
C     WSI=PARTICLE SPECIFIC INTERNAL ENERGY
C     WSU=RADIAL VELOCITY COMPONENT OF PARTICLE
C     WSV=AXIAL VELOCITY COMPONENT OF PARTICLE
 4332 N=NYY                                                         PH3 1960
      IF(IIWS)4335,4335,24                                          PH3 1970
   24 IIWS=-1                                                       PH3 1980
 4333 IF(AMX(K)+AMD(K))9951,4335,4334
C     CALCULATE PACKAGE ENERGY.
 4334 E=((U(K)**2+V(K)**2)/(AMX(K)+AMD(K)))*.5+AIX(K)+AID(K)
C        THE FOLLOWING IS FOR PIC TRANSPORT ONLY
C     SET THE PARTICLE COORDINATES INTO THE
C     PROPER ARRAYS.
 4335 XL(N)=TX                                                      PH3 2010
      YL(N)=TY                                                      PH3 2020
C     SET I AND J OF CELL K(LOCATION OF PARTICLE).
      IW1(N)=I                                                      PH3 2030
      IW2(N)=J                                                      PH3 2040
C     CALCULATE PARTICLE MASS AS
C     =2PI/N*DX/N*DY*XL(N)*RHO.
      AM(N)=TAM*TX*WSR                                              PH3 2050
C        CHECK FOR TYPE OF MASS(X OR . )
 4341 IF(LX)9945,4342,4344                                          PH3 2060
 4342 WS=AM(N)*WSI                                                  PH3 2070
      IF(AM(N)-AMDM)16,15,15                                        PH3 2080
   16 AMDM=AM(N)                                                    PH3 2090
C        NOTE, AID HERE IS INTERNAL ENERGY,
C           NOT SPEIFIC INTRNAL ENERGY.
   15 AID(K)=AID(K)+WS
      PM=PM+AM(N)                                                   PH3 2110
      AMD(K)=AMD(K)+AM(N)
      AM(N)=-AM(N)                                                  PH3 2120
      GO TO 4346                                                    PH3 2130
 4344 WS=AM(N)*WSI                                                  PH3 2140
      IF(AM(N)-AMXM)18,17,17                                        PH3 2150
   18 AMXM=AM(N)                                                    PH3 2160
C        NOTE, AIX HERE IS INTERNAL ENERGY,
C       NOT SPECIFIC INTERNAL ENERGY.
   17 AIX(K)=AIX(K)+WS                                              PH3 2170
      PM=PM+AM(N)                                                   PH3 2180
```

```
C     SUM UP MASS, BOTH COMPONENTS OF MOMENTA
C     AND TOTAL INTERNAL ENERGY IN CELL K.
      AMX(K)=AMX(K)+AM(N)
C       ** NOTE, U AND V ARE NOT VELOCITY COMPONENTS
C      HERE IN PH3, BUT ARE THE RESPECTIVE
C         RADIAL AND AXIAL MOMENTAS.
 4346 U(K)=U(K)+ABS(AM(N))*WSU
      V(K)=V(K)+ABS(AM(N))*WSV
      IF(NY-NPRR)4800,14,9945
   14 NRC=NRC+1
      NPRR=NPRR+NPRI-1
 5001 NYY=1
    3 DO 2 N=2,NPRI
C     SET PARTICLE ARRAYS TO ZERO.
      XL(N)=0.0
      YL(N)=0.0
      AM(N)=0.0
      IW1(N)=0
      IW2(N)=0
    2 CONTINUE
 4800 IF(MX-IB)9946,4880,4028
CALCULATE   ENERGY   FOR   PKG
 4880 IF(IWS)4900,5700,4900
 4900 IF(AMX(K)+AMD(K))9951,5700,4910
 4910 PEE=(U(K)**2+V(K)**2)/(AMX(K)+AMD(K))*.5+AIX(K)+AID(K)
 4930 IF(E)4950,4950,4940
 4940 PEE=PEE-E
 4950 PE=PE+PEE
 5700 CONTINUE
      I=IA
      J=JA
      K=IJ
      L=JT
      GO TO 10000
C                  E R R O R
 9932 NK=4000
      GO TO 9999
 9935 NK=4010
      GO TO 9999
 9936 NK=4011
      GO TO 9999
 9937 NK=4015
      GO TO 9999
 9938 NK=4019
      GO TO 9999
 9939 NK=4077
      GO TO 9999
 9940 NK=4201
      GO TO 9999
 9941 NK=4310
      GO TO 9999
 9945 NK=4341
      GO TO 9999
 9946 NK=4800
      GO TO 9999
 9951 NK=4905
 9999 WRITE (6,8888)NK,I,J,K,L,M,N
```

```
      PRINT 8888,NK,I,J,K,L,M,N                                         PH3 2720
      CALL DUMP                                                         PH3 2730
10000 RETURN                                                            PH3 2740
 8888 FORMAT(1H+/26H1 P H 3 ERROR IN STATEMENTI5,12X,12H INDICES ARE6I7)PH3 2750
      END                                                               PH3 2760
      SUBROUTINE PH4                                                    PH4 0010
C                                                                       INPU0710
C                                                                       PH4 0730
C      ** NOTE, XC AND YC ARE COORDINATES FOR RELOCATING
C       THE ORIGIN FOT THE
C       RHO,INTERNAL ENERGY, AND VELOCITY FITS.                         PH4 0940
C
C     THE ACTUAL COORDINATES USED IN THE FIT
C     SUBROUTINES IS TTX=TX-XC,TTY=TY-YC.                               PH4 0950
      TTX=TX-XC                                                         PH4 0960
      TTY=TY-YC                                                         PH4 0970
      LL=S8                                                             PH4 0980
      GO TO(1,2,3,4,5,6),LL                                             PH4 0990
    1 CALL FIT1                                                         PH4 10[illegible]
      GO TO 7                                                           PH4 1010
    2 CALL FIT2                                                         PH4 1020
      GO TO 7                                                           PH4 1030
    3 CALL FIT3                                                         PH4 1040
      GO TO 7                                                           PH4 1050
    4 CALL FIT4                                                         PH4 1060
      GO TO 7                                                           PH4 1070
    5 CALL FIT5                                                         PH4 1080
      GO TO 7                                                           PH4 1090
    6 CALL FIT6                                                         PH4 1100
    7 RETURN                                                            PH4 1110
      END                                                               FIT10010
      SUBROUTINE FIT1                                                   INPU0710
C                                                                       FIT10730
C                                                                       FIT10940
C                                                                       FIT10950
      WS=SQRT(TTX**2+TTY**2)                                            FIT10960
C     DENSITY                                                           FIT10970
      WSR=TABR(1)+TABR(2)*(TTY-TABR(3))                                 FIT10980
C     ENERGY                                                            FIT10990
      WSI=TABI(1)+TABI(2)*(TTY-TABI(3))                                 FIT11000
C     VELOCITIES                                                        FIT11010
      WS=TABUV(1)+TABUV(2)*(TTY-TABUV(3))                               FIT11020
      WSU=0.0                                                           FIT11030
      WSV=WS                                                            FIT11040
      RETURN                                                            FIT11050
      END                                                               FIT20010
      SUBROUTINE FIT2                                                   INPU0710
C                                                                       FIT20730
C                                                                       FIT20940
C                                                                       FIT20950
      WS=SQRT(TTX**2+TTY**2)                                            FIT20960
C     DENSITY                                                           FIT20970
      WSR=((TTX-TABR(1))/TABR(2))**2+((TTY-TABR(3))/                    FIT20980
     1TABR(4))**2
                                                                        FIT20990
C     ENERGY                                                            FIT21000
      WSI=TABI(1)+TABI(2)*TTX+TABI(3)*TTX**2
```

```
     1+TABI(4)*TTY+TABI(5)*TTY**2                                      FIT21010
C     VELOCITIES                                                       FIT21020
      WSV=TABUV(1)+TABUV(2)*TTY                                        FIT21030
      WSU=TABUV(3)+TABUV(4)*TTY                                        FIT21040
      RETURN                                                           FIT21050
      END                                                              FIT21060
      SUBROUTINE FIT3                                                  FIT30010
C                                                                      INPU0710
C                                                                      FIT30730
C                                                                      FIT30940
C      THIS FIT FOR SIN KZ/KZ ************
      WS=SQRT(TTX**2+TTY**2)                                           FIT30950
C     DENSITY                                                          FIT30960
      WSR=TABR(1)+TABR(2)*(TTY-TABR(3))
      WSA=TTY/TABI(2)
      WSB=WSA*PIDY*2.
      WSC=SIN(WSB)
      WSI=WSC/WSA*TABI(1)
      WS=TABUV(1)+TABUV(2)*(TTY-TABUV(3))
      WSU=0.
      WSV=WS
      WSI=WSI*TABI(3)
C     TABI(3) US SCALE FACTOR FOR YIELD NORMALLY SET TO 1.
      RETURN
      END
      SUBROUTINE FIT4                                                  FIT40010
      RETURN                                                           FIT40020
      END                                                              FIT40030
      SUBROUTINE FIT5
      RETURN
      END
      SUBROUTINE FIT6                                                  FIT60010
      RETURN                                                           FIT60020
      END                                                              FIT60030
      SUBROUTINE OUTPUT                                                OUTP0010

C                                                                      INPU0710
C
C     ******* A 2 MATERIAL CLAM FOR THE TOIL CODE **************
C
C L A M                ******   O U T P U T   ******                   OUTP0020
C                                                                      OUTP0030
C                                                                      OUTP0750
C                                                                      OUTP0970
C               PACKAGES HAVE BEEN READ IN AND PROCESSED               OUTP0980
C               COMPUTE TOTAL ENERGIES AND TOTAL MASSES                OUTP0990
      E=ETH                                                            OUTP1000
      WRITE (6,8104)                                                   OUTP1010
 7001 ND=ND+1                                                          OUTP1020
      IF(E)6000,6000,6001                                              OUTP1030
 6000 AMDM=0.0                                                         OUTP1040
      AMXM=0.0                                                         OUTP1050
      GO TO 7016                                                       OUTP1060
 6001 AMDM=AMDM/2.0                                                    OUTP1070
      AMXM=AMXM/2.0                                                    OUTP1080
 7013 IF(AMDM)9901,9901,7014                                           OUTP1090
 7014 IF(AMXM)9902,9902,7016                                           OUTP1100
```

```
 7016 ETH=0.0                                                          OUTP1110
      TMDZ=0.0                                                         OUTP1120
      TMXZ=0.0                                                         OUTP1130
      DO 7015 I=2,KMAX
 7017 IF(AMD(I))9904,7010,7004
 7010 WSI=0.
      IF(AMX(I))9904,7012,7006
 7004 TMDZ=AMD(I)+TMDZ
      WSI=AID(I)
C       CALCULATE THE SPECIFIC INTERNAL ENERGY
C         FOR(.) MATERIAL IN CELL K.
      AID(I)=AID(I)/AMD(I)
 7005 IF(AMX(I))9904,7008,7006
 7006 WSI=WSI+AIX(I)
C     SUM UP TOTAL (X) MASS IN GRID.
      TMXZ=AMX(I)+TMXZ                                                 OUTP1170
C       CALCULATE THE SPECIFIC INTERNAL ENERGY
C      FOR(X) MATERIAL IN CELL K.
      AIX(I)=AIX(I)/AMX(I)                                             OUTP1180
 7008 WS=AMX(I)+AMD(I)
C     CALCULATE RADIAL AND AXIAL VELOCITIES BY
C     CONSERVING BOTH COMPONENTS OF MOMENTA.
      U(I)=U(I)/WS                                                     OUTP1200
      V(I)=V(I)/WS                                                     OUTP1210
C     SUM UP TOTAL ENERGY IN SYSTEM.
      ETH=((U(I)**2+V(I)**2)/2.)*WS+WSI+ETH
      GO TO 7012                                                       OUTP1230
C       SET FLAGS FOR TYPE OF MATERIAL IN CELL K.
 7012 IF(AMX(I)+AMD(I))2000,2000,2001
 2000 DKE(I)=0.
      GO TO 7015
 2001 IF(AMX(I))2002,2002,2003
 2002 DKE(I)=-1.
      GO TO 7015
 2003 IF(AMD(I))2004,2004,2005
 2004 DKE(I)=-2.0
      GO TO 7015
 2005 DKE(I)=1.0
 7015 CONTINUE
      TMZ=TMDZ+TMXZ                                                    OUTP1250
      WRITE (6,8072)ETH,E,TMDZ,TMXZ,TMZ                                OUTP1260
      IWS=ND-1                                                         OUTP1270
      IWSA=NMAX-ND                                                     OUTP1280
      IWSB=NMAX-1                                                      OUTP1290
      WRITE (6,8073)(IWS,IWSA,IWSB)                                    OUTP1300
 7113 REWIND N7                                                        OUTP1320
C                                                                      OUTP1330
C      WRITE TAPE FOR THE TOIL CODE.
C                                                                      OUTP1350
      IF(PROB)7162,7162,7163                                           OUTP1360
 7163 N3=0                                                             OUTP1370
 7162 WS=555.0                                                         OUTP1380
      WRITE (N7)WS,CYCLE,N3                                            OUTP1390
      WRITE (N7)(Z(I),I=1,MZ)                                          OUTP1400
 7131 WRITE(N7)(U(K),V(K),AMD(K),AMX(K),AID(K),AIX(K),
     1AIX(K),DKE(K),K=1,KMAXA)
      GO TO 7140                                                       OUTP1420
```

```
 7140 CONTINUE                                                          OUTP1430
      WRITE(N7)(X(K),TAU(K),K=1,IMAX)
      WRITE(N7)(Y(K),K=1,JMAX)
      WS=666.0                                                          OUTP1460
C                                                                       OUTP1470
C        EDIT OUT THE VELOCITIES, MASS
C       AND SPECIFIC INTERNAL ENERGIES AS A FUNCTION
C            OF  J FOR ALL I   .
 7161 WRITE (N7)WS,WS,WS                                                OUTP1530
      REWIND N7                                                         OUTP1540
      WRITE (6,8120)T,NC                                                OUTP1550
      IWS=IMAX*JMAX+1                                                   OUTP1560
      CALL SLITE (0)                                                    OUTP1570
      DO 7517 I=1,IMAX                                                  OUTP1580
      CALL SLITE (1)                                                    OUTP1590
      J=JMAXA                                                           OUTP1600
      K=IWS+I                                                           OUTP1610
      DO 7517 JP=1,JMAX                                                 OUTP1620
      J=J-1                                                             OUTP1630
      K=K-IMAX                                                          OUTP1640
 7170 IF(AMX(K)+AMD(K))9905,7517,7175
 7175 CALL SLITET(1,K000FX)                                             OUTP1660
       GO TO(7180,7185),K000FX                                          OUTP1670
C     PRINT OUT CELL QUANTITIES.
 7180 WRITE (6,8080)I,X(I),DX(I)                                        OUTP1680
 7185 WRITE(6,8084)J,Y(J),DY(J),U(K),V(K),AID(K),AIX(K),AMD(K),AMX(K)
 7517 CONTINUE                                                          OUTP1710
      IF(Q000FL)7520,7520,7616                                          OUTP1720
 7616 CONTINUE
      GO TO 7520                                                        OUTP1820
C                 ERROR                                                 OUTP1830
 9901 NK=7013                                                           OUTP1840
      GO TO 9999                                                        OUTP1850
 9902 NK=7014                                                           OUTP1860
      GO TO 9999                                                        OUTP1870
 9904 NK=7005                                                           OUTP1880
      GO TO 9999                                                        OUTP1890
 9905 NK=7170                                                           OUTP1900
 9999 WRITE (6,8888)NK,I,J,K,L,M,N                                      OUTP1910
      PRINT 8888,NK,I,J,K,L,M,N                                         OUTP1920
      CALL DUMP                                                         OUTP1930
 7520 RETURN                                                            OUTP1940
C                 FORMATS                                               OUTP1950
 80720FORMAT(1H ////6H THE =1PE16.9,7X,3HE =E16.9///5H M. =E11.5,5X,4HMXOUTP1960
     1 =E11.5,7X,7HM.+MX =E11.5)                                        OUTP1970
 8073 FORMAT(1H0/17H0PARTICLES  - - -I12,4H DOTI14,2H XI14,6H TOTAL)    OUTP1980
 80800FORMAT(1H0///3H0I=I2,10X,2HX=1PE13.7,10X,3HDX=E13.7/3H0 J10X,1HY13OUTP1990
     1X,2HDY12X,1HU13X,1HV12X,3HAID11X,3HAIX11X,3HAMD11X,3HAMX)         OUTP2000
 8084 FORMAT(I3,3X,1P8E14.7)                                            OUTP2010
 8104 FORMAT(1H /31H THERE ARE NO MORE PACKAGES----)                    OUTP2060
 8120 FORMAT(1H ///18H TAPE DUMP AT TIMEF10.1,7X,5HCYCLEI4)             OUTP2070
 8888 FORMAT(1H+/26H1OUTPUT ERROR IN STATEMENTI5,12X,12H INDICES ARE6I7)OUTP2080
      END                                                               OUTP2090
```

```
      SUBROUTINE PH1                                                    PH1 003
C
C        A TWO MATERIAL OIL
C
C       NOTE,, THE FOLLOWING SET OF DIMENSIONS,
C         COMMON, AND EQUIVALENCE ARE TO BE USED
C               FOR ALL SUBROUTINES EXCEPT
C                 THE CARDS ROUTINE ........
C
C                 D   I   M   E   N   S   I   O   N                    EDIT0060
C                                                                       EDIT0070
      DIMENSION  AM(130),    XL(130),    YL(130),                       EDIT0080
     1U(4500),V(4500),AMD(4500),AMX(4500),AID(4500),AIX(4500),
     2P(4500),DKE(4500),THETA(4500),
     3IW1(130),W2(30),
     4DX(100),X(100),XX(101),DY(100),Y(100),YY(101),
     5TAB(15),    AMK(15),    PK(15),     QK(15),      Z(150),     IZ(150),  EDIT0130
     6TAU(100),PL(200),PR(200),UL(200),UR(200),
     7FLEFT(100),YAMC(100), SIGC(100), GAMC(100)                        EDIT0150
      DIMENSION DMASL(130),DXML(130),DYML(130),DENRG(130)
      COMMON          Z       ,XX     ,UR     ,PR     ,THETA  ,YY       EDIT0160
      COMMON          AID     ,AIX    ,AM     ,AMD    ,AMX    ,AREA     EDIT0170
      COMMON          BIG     ,BOUNCE ,DDXN   ,DDVK   ,DVK    ,DX       EDIT0180
      COMMON          DY      ,E      ,FD     ,FS     ,FX     ,OUT      EDIT0190
      COMMON          P       ,PABOVE ,PBLO   ,PIDTS  ,PPABOV ,PRR      EDIT0200
      COMMON          PUL     ,QDT    ,RC     ,REZ    ,RHO    ,RL       EDIT0210
      COMMON          RR,SIG,GOOFL,SWITCH ,TABLM,TAU                    EDIT0220
      COMMON          TAUDTS  ,TAUDTX ,U      ,UK     ,URR    ,UT       EDIT0230
      COMMON          UU      ,UUU    ,UTEF   ,UVMAX  ,V      ,VABOVE   EDIT0240
      COMMON          VBLO    ,VEL    ,VK     ,VT     ,VTEF   ,VV       EDIT0250
      COMMON          VVABOV  ,VVBLO  ,W2     ,W3     ,WPS    ,WS       EDIT0260
      COMMON          WSA     ,WSB    ,WSC    ,XL     ,XLF    ,XN       EDIT0270
      COMMON          XR      ,YL     ,YLW    ,YN     ,YU     ,ZMAX     EDIT0280
      COMMON          I       ,II     ,IN     ,IR     ,IWS    ,IWSA     EDIT0290
      COMMON          IWSB    ,IWSC   ,IW1    ,J      ,JN     ,JP       EDIT0300
      COMMON          JR      ,K      ,KN     ,KP     ,KR     ,KRM      EDIT0310
      COMMON          L       ,M      ,MA     ,MB     ,MC     ,MD       EDIT0320
      COMMON          ME      ,MZ     ,N      ,NK     ,NKMAX  ,NK1      EDIT0330
      COMMON          NO      ,NR                                       EDIT0340
C                                                                       EDIT0440
C                 E   Q   U   I   V   A   L   E   N   C   E             EDIT0450
C                                                                       EDIT0460
     0EQUIVALENCE      (Z,IZ,PROB),      (Z(2),CYCLE),     (Z(3),DT),     EDIT0470
     1(Z(4),PRINTS),   (Z(5),PRINTL),    (Z(6),DUMPT7),    (Z(7),CSTOP),  EDIT0480
     2(Z(8),PIDY),     (Z(9),TMZ),       (Z(10),GAM),      (Z(11),GAMD),  EDIT0490
     3(Z(12),GAMX),    (Z(13),ETH),      (Z(14),FFA),      (Z(15),FFB),   EDIT0500
     4(Z(16),TMDZ),    (Z(17),TMXZ),     (Z(18),XMAX),     (Z(19),TXMAX), EDIT0510
     5(Z(20),TYMAX),   (Z(21),AMDM),     (Z(22),AMXM),     (Z(23),DNN),   EDIT0520
     6(Z(24),DMIN),    (Z(25),FEF),      (Z(26),DTNA),     (Z(27),CVIS), EDIT0530
     7(Z(28),NPR),     (Z(29),NPRI),     (Z(30),NC),       (Z(31),NPC),   EDIT0540
     8(Z(32),NRC),     (Z(33),IMAX),     (Z(34),IMAXA),    (Z(35),JMAX),  EDIT0550
     9(Z(36),JMAXA),   (Z(37),KMAX),     (Z(38),KMAXA),    (Z(39),NMAX)   EDIT0560
     0EQUIVALENCE      (Z(40),ND),       (Z(41),KDT),      (Z(42),IXMAX), EDIT0570
     1(Z(43),NOD),     (Z(44),NOPR),     (Z(45),NTMAX),    (Z(46),NJMAX), EDIT0580
     2(Z(47),I1),      (Z(48),I2),       (Z(49),I3),       (Z(50),I4),    EDIT0590
     3(Z(51),N1),      (Z(52),N2),       (Z(53),N3),       (Z(54),N4),    EDIT0600
     4(Z(55),N5),      (Z(56),N6),       (Z(57),N7),       (Z(58),N8),    EDIT0610
     5(Z(59),N9),      (Z(60),N10),      (Z(61),N11),      (Z(62),NRM),   EDIT0620
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      6(Z(63),TRAD),      (Z(64),XNRG),      (Z(65),SN),       (Z(66),DXN),      EDIT0630
      7(Z(67),RADER),     (Z(68),RADET),     (Z(69),RADEB),    (Z(70),DTRAD),    EDIT0640
      8(Z(71),REZFCT),    (Z(72),RSTOP),     (Z(73),SHELL),    (Z(74),BBOUND),   EDIT0650
      9(Z(75),TOZONE),    (Z(76),ECK),       (Z(77),SBOUND),   (Z(78),X1)        EDIT0660
      0EQUIVALENCE        (Z(79),X2),        (Z(80),Y1),       (Z(81),Y2),       EDIT0670
      1(Z(82),CABLN),     (Z(83),VISC),      (Z(84),T),        (Z(85),GMAX),     EDIT0680
      2(Z(86),WSGD),      (Z(87),WSGX),      (Z(88),GMADR),    (Z(89),GMAXR),    EDIT0690
      3(Z(90),S1),        (Z(91),S2),        (Z(92),S3),       (Z(93),S4),       EDIT0700
      4(Z(94),S5),        (Z(95),S6),        (Z(96),S7),       (Z(97),S8),       EDIT0710
      5(Z(98),S9),        (Z(99),S10)                                            EDIT0720
C                                                                                EDIT0730
      0EQUIVALENCE        (XX(2),X(1)),      (UR,UL,FLEFT),    (UR(100),YAMC),   EDIT0740
      1(PR(100),SIGC),    (PR,PL,GAMC),      (DKE,THETA),      (UR,TAB),         EDIT0750
      2(UR(16),AMK),      (UR(31),PK),       (UR(46),QK),      (YY(2),Y(1))      EDIT0760
       EQUIVALENCE (AM,DMASL),(XL,DXML),
      1(YL,DYML),(1W1,DENRG)
       DIMENSION PLOT(10)
       DATA PLOT/1H ,1HX,1H.,1HM,1H-/
C                                                                                00000030
C
C        INPUT READS THE TOIL DUMP TAPE OR
C      WILL CALL SUBROUTINE SET'UP WHICH
C      WILL MAKE A DUMP TAPE FOR CERTAIN TYPES OF PROBLEM
       CALL INPUT
C      CDT ROUTINE CALCULATES DT(HYDRO TIME STEP)
C      AND PRESSURES, ADVANCE CYCLE NO. ETC.
   10 CALL CDT
C      IN EDIT, DETERMINE WHETHER TO EXECUTE A LONG
C      PRINT, A SHORT PRINT, A TAPE DUMP, ETC. AND
C      CALCULATE TOTAL ENERGY IN SYSTEM(COMPARE
C      WITH ETH) TOTAL MASS, INTEGRATE TOTAL
C      COMPONENTS OF MOMENTA.
       CALL EDIT
       CALL SLITET(1,KOOOFX)
C       SENSE LITE 1 SIGNIFIES THIS
C      IS THE LAST CYCLE OF THIS RUN $$$$$$$$$$$$$$
C      LITE TURNED ON IN THE EDIT ROUTINE ******
        GO TO(30,20),KOOOFX
C      PH1, INTEGRATE THE MOMENTA EQS. INTEGRATE
C      ENERGY EQUATION(ONLY CHANGES DUE TO WORK
C       TERMS). NO MOVEMENT OF MASS HERE
   20 CALL PH1
C      TRANSPORT MASS ACROSS BOUNDARIES (SOLVE
C      MASS TRANSPORT EQ.) TRANSPORT TERMS IN
C      THE MOMENTA AND ENERGY EQS. LEFT OUT OF
C      PH1, HERE APROXIMATED BY MASS MOVEMENT. CONSERVE
C      MASS, MOMENTA AND TOTAL ENERGY.
       CALL PH2
       GO TO 10
   30 CALL EXIT
       END
C
C      ----------------------------------------------------------------------
C
       SUBROUTINE INPUT                                                          INPU0040
C      ********** A 2 MATERIAL OIL CODE ******************************
       CALL SLITE (3)                                                            INPU1050
```

```
C
C     READ IN COUNTER, FOR THE NO. OF HEADER CARDS.
      READ(5,8009)II
 8009 FORMAT(6I3)
C     READ IN THE HEADER CARDS.
      DO 8010 I=1,II
      READ  (5,8004)IWS
      WRITE (6,8004)IWS
 8010 CONTINUE
    6 CALL CARDS
C     NOTE, OPTION FOR CALLING SETUP.
      IF(PK(3)) 8887,8888,8888
 8888 CALL CARDS
      CALL   SETUP
 8887 CONTINUE
C                 READ TAPE
      GO TO 1000
   10 CONTINUE
      CALL CARDS
C                 EXECUTE  R E S
      GO TO 2000
C
   40 CONTINUE
C     DECREASE T BY DT, SINCE CDT ROUTINE
C     INTEGRATES THE TIME.
      T=T-DTNA
C     ALSO CYCLE NO.
      NC=NC-1
      CYCLE=NC
C     AND NO. OF CYCLES BETWEEN ENERGY CHECKS.
      NPC=NPC-1
      UVMAX=0.0
C     GENERATE DX AND DY FOR ALL I AND J
C     SINCE THEY ARE NOT ON THE DUMP TAPE.
      DX(1)=X(1)
      DO 50 I=2,IMAX
   50 DX(I)=X(I)-X(I-1)
      DY(1)= Y(1)
      DO 55  J=2,JMAX
   55 DY(J)=Y(J)-Y(J-1)
C     EDIT OUT THE Z BLOCK.
      K=1
      DO 80 I=1,3
      L=K+8
      WRITE(6,8005)K,(Z(N),N=K,L)
   80 K=L+1
      K=28
      DO 81 I=1,4
      L=K+8
      WRITE(6,8006)K,(IZ(N),N=K,L)
   81 K=L+1
      K=62
      DO 82 I=1,10
      L=K+8
      WRITE(6,8005)K,(Z(N),N=K,L)
   82 K=L+1
 8005 FORMAT(I4,1X,1P9E12.5)
```

```
 8006 FORMAT(I4,1X,9I7)
.     GO TO 10000                                                       INPU1600
C                                                                       INPU1610
C                                                                       INPU1620
C                                                                       INPU1630
C**** R E A D   T A P E *************************************************INPU1640
 1000 MZ=150                                                            INPU1650
      IWS=0                                                             INPU1660
 1003 REWIND N7
 1004 READ(N7)PR(1),PR(2),N3
C                    NR = NUMBER OF RECORDS                             INPU1690
C     NOTE *****                                                        INPU1700
      NR=N3+5
 1006 IF(PR(1)-555.0)1010,1016,1010                                     INPU1720
 1010 IWS=IWS+1                                                         INPU1730
 1011 IF(MOD(IWS,3))9902,9902,1003                                      INPU1740
 1016 IF(PR(2))1010,1010,1018                                           INPU1750
C     CHECK FOR CORRECT CYCLE NO.
 1018 IF(PK(2)-PR(2))1023,1023,1020                                     INPU1760
 1020 DO 1022 L=2,NR                                                    INPU1770
 1022 READ(N7)DUM
      GO TO 1004                                                        INPU1810
 1023 READ(N7)(Z(I),I=1,MZ)
C     CHECK FOR CORRECT PROBLEM NO.
      IF(ABS(PROB-PK(1))-.01)1024,1024,9901                             INPU1830
 1024 READ(N7)(U(I),V(I),AMD(I),AMX(I),AID(I),AIX(I),
     1P(I),DKE(I),I=1,KMAXA)
      READ(N7)(X(K),TAU(K),K=1,IMAX)
      READ(N7)(Y(K),K=1,JMAX)
 1034 READ(N7)PR(1),PR(2),PR(3)
 1036 IF(PR(1)-555.0)9904,1040,1038                                     INPU1960
 1038 IF(PR(2)-666.0)9905,1040,9905                                     INPU1970
 1040 GO TO 10                                                          INPU1980
C**** END OF READ TAPE   ************************************************INPU1990
C                                                                       INPU2000
C                                                                       INPU2010
C                                                                       INPU2020
C     CALCULATE MAXIMUM GAMMA AND
C     GAMMA/(GAMMA-1.) FOR EACH MATERIAL.
 2000 IF(WSGX)9906,2010,2005                                            INPU2040
 2005 GAMX=1.0/(WSGX-1.0)                                               INPU2050
 2010 WSGX=(GAMX+1.0)/GAMX                                              INPU2060
      GMAXR=GAMX*WSGX                                                   INPU2070
 2012 IF(WSGD)9907,2020,2015                                            INPU2080
 2015 GAMD=1.0/(WSGD-1.0)                                               INPU2090
 2020 WSGD=(GAMD+1.0)/GAMD                                              INPU2100
      GMADR=GAMD*WSGD                                                   INPU2110
      GMAX=WSGD                                                         INPU2120
      IF(WSGD-WSGX)2025,2030,2030                                       INPU2130
 2025 GMAX=WSGX                                                         INPU2140
 2030 GO TO 40                                                          INPU2150
C**** END OF R E S ******************************************************INPU2160
C                                                                       INPU2170
C                                                                       INPU2180
C                    ERROR                                              INPU2190
 9901 NK=1023                                                           INPU2200
      GO TO 9999                                                        INPU2210
```

```
                                                                   INPU2220
 9902 NK=1011                                                      INPU2230
      GO TO 9999                                                   INPU2240
 9904 NK=1036                                                      INPU2250
      GO TO 9999                                                   INPU2260
 9905 NK=1038                                                      INPU2270
      GO TO 9999                                                   INPU2280
 9906 NK=2000                                                      INPU2290
      GO TO 9999                                                   INPU2300
 9907 NK=2012                                                      INPU2310
 9999 NR=1                                                         INPU2340
      CALL DUMP                                                    INPU2350
C                                                                  INPU2360
10000 RETURN                                                       INPU2370
C                                                                  INPU2380
C                  FORMATS                                         INPU2390
 8000 FORMAT(7E11.3,I2)                                            INPU2400
 80040FORMAT(I1,71H                                                INPU2410
     1                       )                                     INPU2430
C                                                                  INPU2440
      END
C
C     ------------------------------------------------------------
C
      SUBROUTINE SETUP                                             EDIT0060
C                D   I   M   E   N   S   I   O   N                 EDIT0070
C
C     TWO  MATERIAL   SETUP
C     PACKAGES MUST BE RECTANGLES.
C     ASSUMPTION OF = DX AND = DY
C     LOAD PK(4)=1.
      M=PK(4)
C     LOAD PK(5)=RIGHT BOUNDARY OF PELLET(I).
      MA=PK(5)
C     LOAD PK(6)=BOTTOM(J)+1 OF PELLET.
      MB=PK(6)
C     LOAD PK(7)=TOP(J) OF PELLET.
      MC=PK(7)
C     LOAD PK(8)=1.
      MD=PK(8)
C     LOAD PK(9)=RIGHT(I)BOUNDARY OF TARGET.
      ME=PK(9)
C     LOAD PK(10)=BOTTOM(J)+1 OF TARGET.
      MZ=PK(10)
C     LOAD PK(11)=TOP(J)OF TARGET.
      N=PK(11)
C     LOAD INITIAL DENSITY INTO Z(115) FOR (X)MATERIAL
C     FOR THE PROJECTILE.
C      AND Z(116) FOR THE DOT MATERIAL(TARGET))
C     LOAD INITIAL PELLET VELOCITY INTO Z(112).
      VTEF=Z(112)
      KMAX=IMAX*JMAX+1
      KMAXA=KMAX+1
      JMAXA=JMAX+1
      IMAXA=IMAX+1
C     CLEAR ALL CELL ARRAYS.
      DO 1 K=1,KMAX
      U(K)=0.0
```

```
      V(K)=0.0
      P(K)=0.0
      AMX(K)=0.0
      AIX(K)=0.0
      AID(K)=0.
      AMD(K)=0.
      DKE(K)=0.
    1 CONTINUE
      DX(1)=DX(1)
      X(1)=DX(1)
      WS=X(1)**2
      PIDY=3.1415927
      TAU(1)=WS*PIDY
C     CALCULATE DX,X,TAU
      DO 10 I=2,IMAX
      X(I)=X(I-1)+DX(1)
      DX(I)=DX(1)
      WSA=X(I)**2
      TAU(I)=PIDY*(WSA-WS)
      WS=WSA
   10 CONTINUE
      Y(1)=DY(1)
C     CALCULATE DY AND Y.
      DO 20 J=2,JMAX
      Y(J)=Y(J-1)+DY(1)
      DY(J)=DY(1)
   20 CONTINUE
      ETH=0.0
      DO 30 I=M,MA
      K=(MB-1)*IMAX+I+1
C     CALCULATE MASS, AND VELOCITY OF PELLET.
      DO 40 J=MB,MC
      AMX(K)=Z(115)*DY(J)*TAU(I)
      V(K)=VTEF
C     CALCULATE TOTAL ENERGY (ETH.)
      ETH=ETH+AMX(K)*(V(K)**2)/2.0
      DKE(K)=-2.
   40 K=K+IMAX
   30 CONTINUE
C     CALCULATE MASS OF TARGET.
      DO 50 I=MD,ME
      K=(MZ-1)*IMAX+I+1
      DO 60 J=MZ,N
      AMD(K)=Z(116)*DY(J)*TAU(I)
      DKE(K)=-1.
   60 K=K+IMAX
   50 CONTINUE
      IMAX=IMAX
      JMAX=JMAX
      SHELL=2.0
      CYCLE=0.0
      DT=0.0
      NMAX=0
      XMAX=X(IMAX)
      TXMAX=XMAX*2.0
      YMAX=Y(JMAX)
      TYMAX=YMAX*2.0
```

```
C     DUMP ON TAPE N7
C
C     WRITE STARTING CONDITIONS FOR TOIL
C
      REWIND N7
      WS=555.0
      WRITE(N7)WS,CYCLE,N3
      WRITE(N7)(Z(I),I=1,150)
      WRITE(N7)(U(I),V(I),AMD(I),AMX(I),AID(I),AIX(I),
     1P(I),DKE(I),I=1,KMAXA)
      WRITE(N7)(X(I),TAU(I),I=1,IMAX)
      WRITE(N7)(Y(I),I=1,JMAX)
      WS=666.0
      WRITE(N7)WS,WS,WS
      REWIND N7
      RETURN
      END
C
C
      SUBROUTINE CARDS                                                  CARD0030
      DIMENSION TABLE(1),CARD(7),LABLE(1)                               CARD0040
      COMMON            TABLE                                           CARD0050
      EQUIVALENCE(TABLE(1),LABLE(1))                                    CARD0070
      WRITE (6,10)                                                      CARD0090
    1 READ  (5,11)IEND,LOC,NUMWPC,(CARD(I),I=1,NUMWPC)                  CARD0100
      WRITE (6,12)IEND,LOC,NUMWPC,(CARD(I),I=1,NUMWPC)                  CARD0110
      DO 4 I=1,NUMWPC                                                   CARD0120
      J=LOC+I-1                                                         CARD0130
      IF(IEND-2)2,5,2                                                   CARD0140
    5 LABLE(J)=IFIX(CARD(I))                                            CARD0150
      GO TO 4                                                           CARD0160
    2 TABLE(J)=CARD(I)                                                  CARD0170
    4 CONTINUE                                                          CARD0180
      IF(IEND-1)1,3,1                                                   CARD0190
    3 RETURN                                                            CARD0200
C                FORMATS                                                CARD0210
   10 FORMAT(20H1TOIL    INPUT CARDS///)
   11 FORMAT(I1,I5,I1,0P7E9.4)                                          CARD0230
   12 FORMAT(1H I4,I7,I3,1P7E14.6)                                      CARD0240
      END                                                               CARD0250
C
C
      SUBROUTINE CDT                                                    CDT 0060
C                                                                       CDT 0780
C     ***************************************************               CDT 0010
C     ********** A 2 MATERIAL OIL CODE **************************
C
C     Z(138) FOR DENSITY CHECK,IF CELL K                                CDT 1030
C     HAS RHO LESS THAN Z(138) ,NO STABILITY CHECK                      CDT 1040
C     DONE IN CELL K                                                    CDT 1050
C     IF (CABLN) GREATER THAN 0, THE DT LOADED WILL REMAIN              CDT 1080
C     CONSTANT.                                                         CDT 1090
C     IF(CABLN) =0. CODE CONTROLS TIME STEP BETWEEN FFA,FFB             CDT 1100
C     IF (CABLN) LESS THAN 0. CODE CONTROLS,BUT AT                      CDT 1110
C      Z(139) OF STABILITY.                                             CDT 1120
C     $$$$$ Z(139) IS A INPUT NO. **********                            CDT 1130
```

```
 3000 VEL=0.0                                                       CDT 1140
 3005 DO 3050 I=1,I1
 3010 K=I+1                                                         CDT [illegible]
 3015 DO 3050 J=1,I2
 3020 IF(AMX(K)+AMD(K))9901,3050,3025                               CDT 1200
C                                                                   CDT 1320
C      CALL EQUATION OF STATE
 3025 CALL ES
 3030 IF(ABS(P(K))-1.0E-10)3035,3035,3040
 3035 P(K)=0.0                                                      CDT 1340
 3040 IF(WSGX-VEL)3050,3050,3045                                    CDT 1350
 3045 VEL=WSGX                                                      CDT 1360
 3050 K=K+IMAX                                                      CDT 1370
 3055 KDT=1                                                         CDT 1380
      UVMAX=-1.0                                                    CDT 1390
 3070 DO 3255 I=1,I1
 3075 K=I+1                                                         CDT 1410
 3095 DO 3255 J=1,I2
 3100 KP=K+IMAX                                                     CDT 1430
      IF(AMX(K)+AMD(K))9901,3255,4                                  CDT 1440
C         IF THE DENSITY IS LESS THAN  Z(138) WHICH IS A
C     INPUT NO, THIS CELL WILL BE BYPASSED
C     FOR STABILITY CONSIDERATIONS.
    4 IF((AMX(K)+AMD(K))/(TAU(I)*DY(J))-Z(138))3255,3255,3115       CDT 1450
 3115 SIG=DX(I)                                                     CDT 1460
 3120 IF (DY(J)-SIG)3125,3130,3130                                  CDT 1470
 3125 SIG=DY(J)                                                     CDT 1480
 3130 IF(Z(148))4000,4000,4001
C     SPEED OF SOUND FOR POLYTROPIC GAS.
 4000 WS=SQRT(GMAX*TAU(I)*DY(J)*ABS(P(K))/(AMX(K)+AMD(K)))
      GO TO 3205
C     SPEED OF SOUND FOR METALS.
 4001 WSA=ABS(P(K))*1.E+4
      WS=Z(148)+Z(149)*(WSA**Z(150))
      WS=WS*1.E-3
 3205 WS=WS/SIG                                                     CDT 1500
 3210 IF(UVMAX-WS)3215,3220,3220                                    CDT 1510
 3215 N10=I                                                         CDT 1520
      N11=J                                                         CDT 1530
      UVMAX=WS                                                      CDT 1540
 3220 IF(NMAX)1,1,2                                                 CDT 1550
    1 CONTINUE                                                      CDT 1560
    3 WS=ABS(U(K))/TAU(I)*X(I)/.5*PIDY                              CDT 1570
      GO TO 3225                                                    CDT 1580
    2 WS=ABS(U(K))/DX(I)                                            CDT 1590
 3225 IF(UVMAX-WS)3230,3235,3235                                    CDT 1600
 3230 UVMAX=WS                                                      CDT 1610
      N10=I                                                         CDT 1620
      N11=J                                                         CDT 1630
 3235 WS=ABS(V(K))/DY(J)                                            CDT 1640
 3240 IF(UVMAX-WS)3245,3250,3250                                    CDT 1650
 3245 N10=I                                                         CDT 1660
      N11=J                                                         CDT 1670
      UVMAX=WS                                                      CDT 1680
 3250 CONTINUE                                                      CDT 1690
 3255 K=K+IMAX                                                      CDT 1700
C     SAME TIME CONTROL OPTIONS THAT
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```
C     EXIST IN OIL
C     N10 AND N11 CONTAIN THE COLUMN
C     AND ROW NO. OF THE CELL THAT IS
C     CONTROLLING DT.
 3260 IF(CABLN)90,91,3300
   90 IF(Z(105)-Z(139))7001,7000,7000
 7000 Z(105)=1.
      GO TO 7002
 7001 Z(105)=Z(105)*Z(106)
 7002 DT=.5/VEL/UVMAX*Z(139)*Z(105)                                     CDT 1730
      GO TO 3295                                                        CDT 1740
   91 WS=UVMAX*DT                                                       CDT 1750
      WSA=0.5/VEL                                                       CDT 1760
 3265 IF(FFA-WSA)3276,3276,3270                                         CDT 1770
 3270 FFA=WSA                                                           CDT 1780
 3276 IF(WS-FFA)3285,3300,3280                                          CDT 1790
 3280 DT=DT/WS*FFB/0.9                                                  CDT 1800
      GO TO 3295                                                        CDT 1810
 3285 IF(WS-FFB)3290,3290,3300                                          CDT 1820
 3290 DT=DT*FFA/WS*0.9                                                  CDT 1830
 3295 KDT=0                                                             CDT 1840
 3300 T=T+DTNA                                                          CDT 1850
   85 IF(DTRAD)9911,80,81                                               CDT 1860
   80 NR=NRM                                                            CDT 1870
   84 WS=NR                                                             CDT 1880
      TRAD=DT/WS                                                        CDT 1890
      GO TO 82                                                          CDT 1900
   81 IWS=DT/DTRAD                                                      CDT 1910
      NR=IWS+1                                                          CDT 1920
   83 IF(NR-NRM)84,84,80                                                CDT 1930
   82 NC=NC+1                                                           CDT 1940
      CYCLE=NC                                                          CDT 1950
      NPC=NPC+1                                                         CDT 1960
 3305 IF(T)9909,3320,3310                                               CDT 1970
 3310 IF(KDT)9910,3315,3320                                             CDT 1980
 3315 WRITE (6,8000)T,DTNA,DT                                           CDT 1990
 3320 DTNA=DT                                                           CDT 2000
      GO TO 3325                                                        CDT 2020
 9901 NK=3020                                                           CDT 2030
      GO TO 9999                                                        CDT 2040
 9909 NK=3305                                                           CDT 2050
      GO TO 9999                                                        CDT 2060
 9910 NK=3310                                                           CDT 2070
      GO TO 9999                                                        CDT 2080
 9911 NK=85                                                             CDT 2090
 9999 NR=2                                                              CDT 2100
C     ***************                                                   CDT 2120
      CALL DUMP                                                         CDT 2130
 3325 RETURN                                                            CDT 2140
 8000 FORMAT (17HOCHANGE DT ... T=1PE9.3,11H    DT(N)=1PE9.3,13H      DTCDT 2150
     1(N+1)=1PE9.3)                                                     CDT 2160
      END
C
C     ----------------------------------------------------
C                                                                       PH1 0030
      SUBROUTINE PH1
C     ********** A 2 MATERIAL OIL CODE ***************************
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```
C                                                                      PH1 0990
C     SINCE WE INITIALIZE THE BOUNDARY CONDITION
C     AT THE LEFT FOR THE FIRST COLUMN, AND THE
C     BOTTOM BOUNDARY CONDITION OF THE FIRST CELL,
C     WE NEED ONLY CONCERN OURSELVES WITH
C     CALCULATING QUANTITIES AT THE TOP AND RIGHT
C     OF EACH CELL, SINCE THE LEFT AND BOTTOM
C     HAVE ALREADY BEEN CALCULATED.
C      ****** STANDARD PH.1 VELOCITIES AT CENTER OF CELL *****      PH1 1010
C     INTEGRATION OF VELOCITIES AND INTERNAL ENERGIES                 PH1 1020
C     REQUIRING 2 PASSES                                              PH1 1030
      ETH1=0.
      NRT=0
      NRC=0
 8000 VEL=1.0                                                         PH1 1090
C     INITIALIZE MID-POINTS OF FIRST AND SECOND CELL
C     IN THE R DIRECTION.
 3301 RC=DX(1)/2.0                                                    PH1 1100
      RR=(X(1)+X(2))/2.0                                              PH1 1110
C     AXIS OF SYMMETRY BOUNDARY CONDITIONS
C
 3304 K=2                                                             PH1 1120
      DO 3302 J=1,JMAX                                                PH1 1130
      PL(J)=P(K)                                                      PH1 1140
      UL(J)=0.0                                                       PH1 1150
 3302 K=K+IMAX                                                        PH1 1160
C     FIRST PASS, CALCULATE U AND V TILDA, AND
C     THE WORK TERMS USING PRE-PHI VELOCITIES.
C     SECOND PASS, CALCULATE ONLY THE WORK TERMS
C     USING THE NEW VELOCITIES (U AND V TILDA)
      DO 3360 I=1,I1
    8 K=I+1
      IF(CVIS)7002,7003,7003                                          PH1 1240
C     BOTTOM BOUNDARY IS TRANSMITTIVE.
 7002 VBLO=V(K)                                                       PH1 1250
      PBLO=0.0                                                        PH1 1260
      GO TO 7004                                                      PH1 1270
C     BOTTOM BOUNDARY IS REFLECTIVE.
 7003 VBLO=0.0                                                        PH1 1280
      PBLO=P(K)                                                       PH1 1290
 7004 TAUDTS=TAU(I)*DT                                                PH1 1300
    4 DO 3348 J=1,I2
      PIDTS=1.0/(PIDY*DT*DY(J))                                       PH1 1360
C     K IS INDEX OF CELL IN QUESTION.
C     N IS INDEX OF CELL ABOVE.
      N=K+IMAX                                                        PH1 1370
      IF(VEL)3305,3305,3303                                           PH1 1380
 3303 CONTINUE
 3305 IF(AMD(K)+AMX(K))9902,3340,3306                                 PH1 1400
 3306 IF(IMAX-I)9903,3311,3310                                        PH1 1410
 3310 IF(AMD(K+1)+AMX(K+1))9904,3312,3314                             PH1 1420
C     WE ARE AT THE RIGHT BOUNDARY OF THE GRID,
C     SET PRESSURE GRADIENT TO. ZERO, AND MODIFY
C     ETH.
 3311 PRR=PL(J)                                                       PH1 1430
 3307 ETH=ETH-PRR*U(K)/PIDTS*RC                                       PH1 1440
      GO TO 3313                                                      PH1 1450
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C     THE BOUNDARY CONDITION FOR A EMPTY CELL ON
C     THE RIGHT, THE PRESSURE AT THE RIGHT
C     INTERFACE=0. AND THE VELOCITY IS THAT
C     OF THE CELL CENTER.
 3312 PRR=0.0                                                   PH1 1460
 3313 URR=RC*U(K)                                               PH1 1470
      GO TO 3316                                                PH1 1480
C      CALCULATE PRESSURE AND RU AT INTERFACE I
 3314 PRR=(P(K)+P(K+1))/2.0                                     PH1 1490
 3315 URR=(U(K)*RC+U(K+1)*RR)/2.0                               PH1 1500
 3316 IF(JMAX-J)9905,3318,3320                                  PH1 1510
C     SET PRESSURE GRADIENT TO. ZERO, FOR TOP OF
C     GRID, AND MODIFY ETH.
 3318 PABOVE=PBLO                                               PH1 1520
 3319 ETH=ETH-PABOVE*V(K)/2.0*TAUDTS                            PH1 1530
      GO TO 3323                                                PH1 1540
 3320 IF(AMD(N)+AMX(N))9906,3322,3324                           PH1 1550
C     CELL ABOVE IS EMPTY, SET TOP BOUNDARY
C     CONDITIONS, PRESSURE AT TOP SURFACE=0.
C     AND VELOCITY = THAT OF CELL.
 3322 PABOVE=0.0                                                PH1 1560
 3323 VABOVE=V(K)                                               PH1 1570
      GO TO 3328                                                PH1 1580
C     CALCULATE PRESSURE AT INTERFACE (J)
 3324 PABOVE=(P(K)+P(N))/2.0                                    PH1 1590
      IF(CVIS)7001,3325,3325                                    PH1 1600
 7001 IF(1-J)3325,7000,9905
C     BOTTOM BOUNDARY CONDITION OF GRID IS REFLECTIVE,
C     AND WE HAVE ALREADY SET THE CONDITIONS.
C
C     BOTTOM BOUNDARY OF GRID IS TRANSMITTIVE, SET
C     PRESSURE GRADIENT TO ZERO AND MODIFY ETH.
 7000 PBLO=PABOVE                                               PH1 1630
      ETH=ETH+PBLO*V(K)/2.0*TAUDTS                              PH1 1640
C     CALCULATE VELOCITY AT INTERFACE (J)
 3325 VABOVE=(V(K)+V(N))/2.0                                    PH1 1650
 3328 IF(VEL)9907,3404,3400                                     PH1 1660
C     CALCULATE THE U AND V TILDA QUANTITIES
 3400 V(K)=V(K)+(PBLO-PABOVE)*TAUDTS/(AMD(K)+AMX(K))            PH1 1670
 3402 U(K)=U(K)+(PL(J)-PRR)/(AMX(K)+AMD(K))*RC/PIDTS*2.0        PH1 1710
C     CHECK FOR ADVANCING ACTIVE GRID COUNTERS IN
C     THE R DIRECTION.
 3404 IF(I-I1)6016,6005,6005
 6005 IF(U(K))6605,6606,6605
 6605 NRC=1
 6606 IF(V(K))6607,6004,6607
 6607 NRC=1
 6004 IF(AIX(K)+AID(K))6015,6016,6015
 6015 NRC=1
 6016 CONTINUE
 6044 WS=(VBLO-VABOVE)*TAUDTS/2.0*P(K)
C     CALCULATE THE CHANGE IN INTERNAL ENERGY
C     DUE TO PRESSURE FORCES ONLY.
      DE=WS+(UL(J)-URR)/PIDTS*P(K)
 3405 CONTINUE
 3331 IF(AMD(K))9908,3332,3334                                  PH1 1770
 3332 AIX(K)=AIX(K)+DE/AMX(K)
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```
      GO TO 3342
 3334 IF(AMX(K))9909,3336,3338                                     PH1 1800
 3336 AID(K)=AID(K)+DE/AMD(K)
      GO TO 3342
C     CONVERT TO SPECIFIC INTERNAL
C     ENERGY FOR EACH MATERIAL.
 3338 FS=AMX(K)/DKE(K)+AMD(K)/(1.-DKE(K))
      WSD=DE/(1.-DKE(K))/FS+AID(K)
      WSX=DE/DKE(K)/FS+AIX(K)
 1022 AIX(K)=WSX                                                   PH1 2220
      AID(K)=WSD                                                   PH1 2230
      GO TO 3342                                                   PH1 2240
C     CAME HERE BECAUSE CELL IN QUESTION IS EMPTY.
C     SET INTERFACE QUANTITIES ASSUMING CELL ABOVE
C     AND TO THE RIGHT ARE NOT VOID.
 3340 PRR=0.0                                                      PH1 2250
      URR=U(K+1)*RR                                                PH1 2260
      PABOVE=0.0                                                   PH1 2270
      VABOVE=V(N)                                                  PH1 2280
C     SET RIGHT QUANTITIES TO THE LEFT (FOR
C     NEXT COLUMN SWEEP) AND ABOVE QUANTITIES
C     TO BELOW FOR NEXT CELL ABOVE.
 3342 VBLO=VABOVE                                                  PH1 2290
      PL(J)=PRR                                                    PH1 2300
      UL(J)=URR                                                    PH1 2310
      K=N                                                          PH1 2320
 3348 PBLO=PABOVE                                                  PH1 2330
C     CHECK FOR ADVANCING ACTIVE GRID COUNTERS
C     IN (J) DIRECTION.
      LL=K-IMAX
      IF(U(LL))6000,6001,6000
 6000 NRT=1
 6001 IF(V(LL))6002,6003,6002
 6002 NRT=1
 6003 IF(AIX(LL)+AID(LL))6017,6018,6017
 6017 NRT=1
 6018 CONTINUE
 3355 RC=RR                                                        PH1 2340
      RR=(X(I+1)+X(I+2))/2.0                                       PH1 2350
 3360 CONTINUE                                                     PH1 2360
 3361 IF(VEL)9911,7030,3363
 3363 VEL=0.0                                                      PH1 2380
C     RECYCLE FOR SECOND PASS.
      GO TO 3301                                                   PH1 2390
C                 ERROR                                            PH1 2400
 9902 NK=3305                                                      PH1 2410
      GO TO 9999                                                   PH1 2420
 9903 NK=3306                                                      PH1 2430
      GO TO 9999                                                   PH1 2440
 9904 NK=3310                                                      PH1 2450
      GO TO 9999                                                   PH1 2460
 9905 NK=3316                                                      PH1 2470
      GO TO 9999                                                   PH1 2480
 9906 NK=3320                                                      PH1 2490
      GO TO 9999                                                   PH1 2500
 9907 NK=3328                                                      PH1 2510
      GO TO 9999                                                   PH1 2520
```

```
 9908 NK=3331
      GO TO 9999
 9909 NK=3334
      GO TO 9999
 9911 NK=3361
 9999 NR=3
C     ****************
      CALL DUMP
C     SET VELOCITIES AND INTERNAL ENERGY
C     (FOR SMALL VALUES) TO ZERO.
C        ALSO NEGATIVE INTERNAL ENERGIES
 7030 DO 10 K=2,KMAX
      IF(ABS(V(K))-Z(146))3401,3401,11
 3401 ETH1=ETH1+(AMX(K)+AMD(K))/2.*(V(K)**2)
      V(K)=0.
   11 IF(ABS(U(K))-Z(146))3403,3403,12
 3403 ETH1=ETH1+(AMX(K)+AMD(K))/2.*(U(K)**2)
      U(K)=0.
   12 CONTINUE
      IF(ABS(AIX(K)) -Z(145)) 8002,8002,8003
 8002 ETH1=ETH1+AMX(K)*AIX(K)
      AIX(K)=0.
 8003 IF(ABS(AID(K)) -Z(145)) 8004,8004,8005
 8004 ETH1=ETH1+AMD(K)*AID(K)
      AID(K)=0.
 8005 CONTINUE
   10 CONTINUE
C     INCREASE ACTIVE GRID COUNTERS.
      I1=I1+NRC
      I2=I2+NRT
      ETH=ETH-ETH1
      IF(I1-IMAX)6100,6100,6200
 6200 I1=IMAX
 6100 IF(I2-JMAX)6201,6201,6202
 6202 I2=JMAX
 6201 RETURN
      END
C
C     ----------------------------------------------------------------
C
      SUBROUTINE PH2
C     ********** A 2 MATERIAL OIL CODE ***************************
C
C     FOR X MATERIAL
C     AMPY = MASS AT TOP
C     AMUT = RADIAL MOMENTUM
C     AMVT = AXIAL MOMENTUM
C     DELET = SPECIFIC ENERGY
C
C     FOR DOT MATERIAL
C     TDM = MASS AT TOP
C     TDXM = RADIAL MOMENTUM
C     TDYM = AXIAL MOMENTUM
C     TDTE = SPECIFIC ENERGY
C
C     FOR X MATERIAL
C     AMMP = MASS AT RIGHT
```

```
C       AMUR = RADIAL MOMENTUM
C       AMVR = AXIAL MOMENTUM
C       DELER = SPECIFIC ENERGY
C
C       FOR DOT MATERIAL
C       RDM = MASS AT RIGHT
C       RDXM = RADIAL MOMENTUM
C       RDYM = AXIAL MOMENTUM
C       RDTE = SPECIFIC ENERGY
C
C       FOR X MATERIAL
C       AMMY = MASS AT BOTTOM
C       AMMU = RADIAL MOMENTUM
C       AMMV = AXIAL MOMENTUM
C       DELEB = SPECIFIC ENERGY
C
C       FOR DOT MATERIAL
C       BDM = MASS AT BOTTOM
C       BDXM = RADIAL MOMENTUM
C       BDYM = AXIAL MOMENTUM
C       BDTE = SPECIFIC ENERGY
C
C       FOR X MATERIAL
C       GAMC = MASS AT THE LEFT
C       FLEFT = RADIAL MOMENTUM
C       YAMC = AXIAL MOMENTUM
C       SIGC = SPECIFIC ENERGY
C
C       FOR DOT MATERIAL
C       DMASL = MASS AT THE LEFT
C       DXML = RADIAL MOMENTUM
C       DYML = AXIAL MOMENTUM
C       DENRG = SPECIFIC ENERGY
        ETH1=0.
        RECYC=0.
        NRT=0                                                           PH2 1020
        NRC=0                                                           PH2 1030
        REZ=0.0                                                         PH2 1040
        CALL SLITE (0)                                                  PH2 1050
        PIDTS=1.0/(PIDY*DT)                                             PH2 1060
C       SET BOUNDARY CONDITIONS FOR THE AXIS OF SYMMETRY
  101   DO 103 J=1,JMAX                                                 PH2 1070
  102   GAMC(J)=0.0                                                     PH2 1080
        FLEFT(J)=0.0                                                    PH2 1090
        YAMC(J)=0.0                                                     PH2 1100
        SIGC(J)=0.0                                                     PH2 1110
        DMASL(J)=0.
        DXML(J)=0.
        DYML(J)=0.
        DENRG(J)=0.
  103   CONTINUE                                                        PH2 1120
C       BEGIN DO LOOP ON I
  104   DO 547 I=1,I1                                                   PH2 1130
        J=1                                                             PH2 1140
  105   K=I+1                                                           PH2 1150
   80   IF(AMX(K)+AMD(K))9900,97,81
   81   IF(V(K))82,97,97                                                PH2 1170
```

```
C       NO MASS FLUX
    97 AMMV=0.0                                                    PH2 1180
       BDYM=0.
       GO TO 98
C       CHECK BOTTOM BOUNDARY OF GRID
    82 IF(AMX(K))9900,2,3
C       DOT ONLY
     2 ND=1
       GO TO 6
     3 IF(AMD(K))9900,4,5
C       X ONLY
     4 ND=0
       GO TO 6
C       MIXED CELL
     5 ND=-1
C       MASS OUT OF THE BOTTOM OF THE GRID
     6 WS=(AMX(K)+AMD(K))*V(K)/DY(J)*DT
C       CHECK FOR MORE THAN EMPTYING THE CELL
     7 IF(WS+AMX(K)+AMD(K))8,9,9
     8 AMMY=-AMX(K)
       BDM=-AMD(K)
       GO TO 85
C       THE RESPECTIVE FLUXES ARE PROPORTIONATE TO THE MASSES
     9 WSA=AMX(K)+AMD(K)
       AMMY=WS*AMX(K)/WSA
       BDM=WS*AMD(K)/WSA
    85 IF(CVIS)106,99,99
C       BOTTOM BOUNDARY IS TRANSMITTIVE.
   106 WS=(U(K)**2+V(K)**2)/2.
       IF(ND)11,10,11
C       X MATERIAL ONLY
    10 AMMU=AMMY*U(K)
       AMMV=AMMY*V(K)
       DELEB=AIX(K)+WS
       ETH=ETH+AMMY*DELEB
       GO TO 107
C       DOT FOR SURE AND PERHAPS X ALSO
    11 BDXM=BDM*U(K)
       BDYM=BDM*V(K)
       BDTE=AID(K)+WS
       ETH=ETH+BDM*BDTE
       IF(ND)10,107,107
C       BOTTOM BOUNDARY IS REFLECTIVE
    99 AMMV=2.*AMMY*V(K)
       BDYM=2.*BDM*V(K)
    98 AMMY=0.
       BDM=0.
       AMMU=0.
       BDXM=0.
       DELEB=0.
       BDTE=0.
C       BEGIN DO LOOP IN THE J DIRECTION
   107 DO 546 J=1,I2                                               PH2 1340
   108 L=K+IMAX                                                    PH2 1350
       VEL=0.0                                                     PH2 1390
       FS=0.0                                                      PH2 1400
C       BEGIN CALCULATION OF VABOVE.
```

```
  210 IF(JMAX-J)211,211,207
C     AT TOP BOUNDARY OF GRID.
  211 VEL=1.0
      GO TO 208
  207 IF(AMX(L)+AMD(L))215,215,214
  214 IF(AMX(K)+AMD(K))216,216,209
  216 VABOVE=V(L)
      GO TO 212
  215 IF(AMX(K)+AMD(K))205,205,208
  205 VABOVE=0.0
      GO TO 212
  208 VABOVE=V(K)
      GO TO 212
  209 VABOVE=(V(K)+V(L))/2.0
  212 CONTINUE
C     NOW WE HAVE VABOVE
C     BEGIN CALCULATION OF URIGHT
  404 IF(IMAX-I)412,412,405
  405 IF(AMX(K+1)+AMD(K+1))411,411,409
  409 IF(AMX(K)+AMD(K))410,410,407
  410 URR=U(K+1)
      GO TO 408
  411 IF(AMX(K)+AMD(K))403,403,406
  403 URR=0.0
      GO TO 408
  412 FS=1.0
  406 URR=U(K)
      GO TO 408
  407 URR=(U(K)+U(K+1))/2.0
  408 CONTINUE
  109 CONTINUE
C     CHECK HERE FOR EMPTYING THE PROJECTILE FOR
C     IMPACT PROBLEMS
C     Z(112) = INITIAL AXIAL VELOCITY
C     Z(113) = EPSILONICS, LIKE .05
  301 IF(VABOVE)300,304,302
  302 IF(AMX(K)+AMD(K))9900,304,8800
 8800 IF(J-1)9900,303,8801
 8801 KP=K-IMAX
      IF(AMX(KP)+AMD(KP))9900,8803,303
 8803 IF(ABS(VABOVE-Z(112))/Z(112)-Z(113))306,303,303
  303 M=K
      JJ=J
      GO TO 307
  304 AMPY=0.0
      TDM=0.
  308 AMUT=0.0
      TDXM=0.
      AMVT=0.0
      TDYM=0.
      DELET=0.0
      TDTE=0.
      GO TO 501
  300 IF(VEL)9901,305,304
  305 IF(AMX(L)+AMD(L))9903,304,306
  306 M=L
      JJ=J+1
```

```
  307 IF(VEL)6130,6130,6140                                          PH2 1900
 6130 WSA=(V(K)+V(L))/2.0
      WSB=1.0+(V(L)-V(K))/(DY(JJ)*SBOUND)*DT                         PH2 1920
      VABOVE=WSA/WSB                                                 PH2 1930
C     HERE WE HAVE CALCULATED THE MASS FLUX AT THE TOP,
C     THIS MAY CONSIST OF BOTH X AND DOT
C     MATERIAL, NO DISTINCTION YET.
 6140 AMPY=(AMX(M)+AMD(M))*VABOVE/DY(JJ)*DT
  501 IF(URR)500,504,502                                             PH2 1950
  502 IF(AMX(K)+AMD(K))9900,504,503
  503 M=K                                                            PH2 1970
      N=I                                                            PH2 1980
      GO TO 508                                                      PH2 1990
  504 AMMP=0.0                                                       PH2 2000
      AMUR=0.0                                                       PH2 2010
      AMVR=0.0                                                       PH2 2020
      DELER=0.0                                                      PH2 2030
      RDM=0.
      RDXM=0.
      RDYM=0.
      RDTE=0.
      GO TO 9500
  500 IF(FS)9905,506,504                                             PH2 2050
  506 IF(AMX(K+1)+AMD(K+1))9904,504,507
  507 M=K+1                                                          PH2 2070
      N=I+1                                                          PH2 2080
  508 IF(FS)6100,6100,6110                                           PH2 2090
 6100 WSA=(U(K)+U(K+1))/2.
      WSB=1.0+(U(K+1)-U(K))/(DX(N)*SBOUND)*DT                        PH2 2110
      URR=WSA/WSB                                                    PH2 2120
 6110 DEN=(AMX(M)+AMD(M))/TAU(N)
C     HERE WE HAVE CALCULATED THE MASS FLUX AT THE
C     RIGHT, THIS MAY CONSIST OF BOTH X AND DOT
C     MATERIAL, NO DISTINCTION MADE YET
      AMMP=DEN/PIDTS*X(I)/.5*URR                                     PH2 2140
C
C
C     BEGIN HERE TO CALCULATE THE FLUX FOR
C     EACH MATERIAL, THE FIRST PASS THROUGH,
C     WE CALCULATE THE FLUX FOR BOTH
C     MATERIALS (IF NECESSARY) AT THE TOP, THE
C     SECOND PASS IS FOR THE RIGHT SIDE.
C
C     NOTE, THE RULES TO FOLLOW FOR
C     TRANSPORTING OF BOTH MATERIALS ARE
C     EXPLAINED IN DETAIL IN THIS REPORT
C
 9500 IF(AMPY)13,26,4600
 4600 IF(AMX(L)+AMD(L))9900,170,14
  170 IF(AMX(K))171,171,172
  172 IF(AMD(K))173,173,722
  171 CONTINUE
  174 TDM=AMPY
      GO TO 733
  173 GO TO 26
   13 IF(AMX(K)+AMD(K))9900,190,14
  190 IF(AMX(L))191,191,192
```

```
  192 IF(AMD(L))193,193,23
  191 IF(AMD(L)+AMPY)195,194,194
  194 TDM=AMPY
      GO TO 733
  195 GO TO 733
  193 IF(AMX(L)+AMPY)197,26,26
  197 GO TO 26
   14 IF(AMX(L))9900,16,18
   16 ND=1
      GO TO 17
   18 IF(AMD(L))9900,19,20
   19 ND=0
      GO TO 17
   20 ND=-1
   17 IF(AMX(K))9900,73,75
   73 NX=1
      GO TO 720
   75 IF(AMD(K))9900,76,51
   76 NX=0
      GO TO 720
   51 NX=-1
  720 IF(AMPY)22,26,726
   22 IF(NX)24,25,25
   25 IF(ND)15,193,28
   26 TDM=0.
      GO TO 27
   24 IF(ND)23,193,28
   23 IF(AMX(K)+AMD(K)) 975,975,976
  975 KK=L
      GO TO 977
  976 KK=K
  977 WS=AMX(KK)+AMD(KK)
      WSA=AMPY
      AMPY=WSA*AMX(KK)/WS
      TDM=WSA*AMD(KK)/WS
  252 CONTINUE
      GO TO 27
   28 TDM=AMPY
      IF(TDM+AMD(L)) 732,732,733
  732     TDM = -AMD(L)
  733 AMPY=0.
      GO TO 27
   15 IF(NX)9900,29,31
   29 IF(AMX(L)+AMPY)32,26,26
   32 WS=AMX(L)+AMPY
      AMPY=-AMX(L)
      IF(AMX(L))9401,9401,33
 9401 AMPY=0.
   33 IF(WS+AMD(L))35,34,34
   34 TDM=WS
      GO TO 27
   35 TDM=-AMD(L)
      GO TO 27
   31 IF(AMD(L)+AMPY)721,9940,9940
 9940 TDM=AMPY
      AMPY=0.
      GO TO 27
```

```
  721 TDM=-AMD(L)
   36 WS=AMD(L)+AMPY
   37 IF(WS+AMX(L))39,38,38
   38 AMPY=WS
      GO TO 27
   39 AMPY=-AMX(L)
      GO TO 27
  722 IF(AMX(L)+AMD(L)) 972,972,970
  972 KK=K
      GO TO 971
  970 KK=L
  971 WS=AMX(KK)+AMD(KK)
      WSA=AMPY
      AMPY=WSA*AMX(KK)/WS
      TDM=WSA*AMD(KK)/WS
  182 CONTINUE
 9971 CONTINUE
      G^ TO 27
  726 IF(ND)41,40,40
   40 IF(NX)42,730,171
  730 CONTINUE
      GO TO 26
   41 IF(NX)722,173,171
   42 IF(ND)9900,60,724
   60 IF(AMX(K)-AMPY)723,26,26
  723 WS=AMX(K)-AMPY
      AMPY=AMX(K)
   43 IF(WS+AMD(K))46,45,45
   45 TDM=-WS
      GO TO 27
   46 TDM=AMD(K)
      GO TO 27
  724 IF(AMD(K)-AMPY)70,128,128
  128 TDM=AMPY
      AMPY=0.
      GO TO 27
   70 TDM=AMD(K)
      WS=AMD(K)-AMPY
   47 IF(WS+AMX(K))49,48,48
   48 AMPY=-WS
      GO TO 27
   49 AMPY=AMX(K)
      GO TO 27
   27 CONTINUE
      IF(RECYC)152,150,152
  150 RECYC=1.
      SAVE1=AMPY
      SAVE2=TDM
      ISAVE1=K
      ISAVE2=L
 9403 L=K+1
 9601 AMPY=AMMP
      TDM=0.
      GO TO 9500
  152 AMMP=AMPY
      RDM=TDM
      AMPY=SAVE1
```

```
      TDM=SAVE2
      K=ISAVE1
      L=ISAVE2
      RECYC=0.
C
C     NOW, WE HAVE THE 4 POSSIBLE FLUXES,
C     NOW BEGIN CHECKING FOR PREFERENTIAL
C     MASS MOVEMENT BECAUSE OF CHOICE OF
C     INDEXING.
C     THE LOGIC OF CHECKING INVOLVES LOOKING
C     AHEAD IN THE J AND I DIRECTIONS, THE
C     PROGRAM CONTINUES FOR THE NEXT 5
C     PAGES OR SO UP TO STATEMENT NO. 5500
C
 3006 IF(GAMC(J)+DMASL(J))3007,3002,3002
 3007 WS=AMX(K)+GAMC(J)
      WSA=AMD(K)+DMASL(J)
      GO TO 3008
 3002 WS= AMX(K)
      WSA=AMD(K)
 3008 IF(AMMY+BDM)3009,3010,3010
 3009 WS=WS+AMMY
      WSA=WSA+BDM
 3010 IF(AMPY+TDM)3012,3013,3011
 3013 TF=0.
      GO TO 3014
 3012 TF=-1.
      GO TO 3014
 3011 TF=1.
 3014 IF(AMMP+RDM)3017,3016,3015
 3016 TR=0.
      GO TO 3018
 3017 TR=-1.
      GO TO 3018
 3015 TR=1.0
 3018 IF(TF)3030,3019,3019
 3019 IF(TR)3025,3025,3020
 3020 IF(WS-AMPY-AMMP)3021,3022,3022
 3021 WSS=AMPY+AMMP
      AMPY=AMPY/WSS*WS
      AMMP=AMMP/WSS*WS
 3022 IF(WSA-TDM-RDM)3023,3024,3024
 3023 WSS=TDM+RDM
      TDM=TDM/WSS*WSA
      RDM=RDM/WSS*WSA
      GO TO 3024
 3025 IF(WS-AMPY)3026,3027,3027
 3026 AMPY=WS
 3027 IF(WSA-TDM)3028,3100,3100
 3028 TDM=WSA
      GO TO 3100
 3030 IF(TR)3100,3100,3040
 3040 IF(WS-AMMP)3050,3051,3051
 3050 AMMP=WS
 3051 IF(WSA-RDM)3052,3100,3100
 3052 RDM=WSA
 3100 IF(TF)3159,3200,3200
```

```
3159 IF(VEL)3101,3101,3200
3101 IF(FS)3103,3103,3102
3102 FRA=U(L)
     GO TO 3104
3103 FRA=(U(L)+U(L+1))/2.
3104 IF(FRA)3158,3158,3105
3158 FRA=0.
     GO TO 3150
3105 FRA=FRA*(AMX(L)+AMD(L))/(TAU(I)*DY(J))*2.*PIDY
    1*X(I)*DY(J+1)*DT
3150 IF(J+1-JMAX)3152,3151,3152
3151 FTA=V(L)
     KA=L
     GO TO 3154
3152 KA=L+IMAX
3153 FTA=(V(L)+V(KA))*.5
3154 IF(FTA)3155,3155,3157
3155 FTA=0.
     GO TO 3156
3157 FTA=FTA*(AMX(L)+AMD(L))*DT/DY(J)
3156 IF(DKE(L))3166,3200,3166
3166 GO TO 3500
3500 IF(GAMC(J+1)+DMASL(J+1))3502,3501,3501
3501 WS1=AMX(L)
     WS2=AMD(L)
     GO TO 3503
3502 WS1=AMX(L)-GAMC(J+1)
     WS2=AMD(L)-DMASL(J+1)
3503 IF(AMPY+TDM)3504,3162,3162
3162 WS=0.
     WSA=0.
     GO TO 3505
3504 WS=AMPY
     WSA=TDM
3505 IF(FTA)3700,3700,3506
3506 IF(DKE(L))3900,3508,3508
3900 IF(DKE(L)+1.)3507,3509,3509
3507 WS=WS-FTA
     GO TO 3700
3509 WSA=WSA-FTA
     GO TO 3700
3508 IF(DKE(KA))3901,3901,3510
3901 IF(DKE(L)+1.0)3515,3511,3511
3510 FTAX=AMX(KA)/(AMX(KA)+AMD(KA))*FTA
     FTAD=AMD(KA)/(AMX(KA)+AMD(KA))*FTA
     GO TO 3520
3511 FTAD=FTA
3512 IF(AMD(L)-FTAD)3514,3513,3513
3513 FTAX=0.
     GO TO 3520
3514 FTAX=FTAD-AMD(L)
     FTAD=AMD(L)
     GO TO 3520
3515 FTAX=FTA
3516 IF(AMX(L)-FTAX)3517,3518,3518
3518 FTAD=0.
     GO TO 3520
```

```
FTAD=FTAX-AMX(L)
FTAX=AMX(L)
GO TO 3520
WS=WS-FTAX
WSA=WSA-FTAD
GO TO 3700
IF(FRA)3800,3800,3701
IF(DKE(L))3902,3902,3708
IF(DKE(L)+1.)3702,3703,3703
WSA=WSA-FRA
GO TO 3800
WS=WS-FRA
GO TO 3800
IF(DKE(L+1))3903,3903,3710
IF(DKE(L+1)+1.)3715,3711,3711
FTAX=AMX(L+1)/(AMX(L+1)+AMD(L+1))*FRA
FTAD=AMD(L+1)/(AMX(L+1)+AMD(L+1))*FRA
WS=WS-FTAX
WSA=WSA-FTAD
GO TO 3800
FTAD=FRA
IF(AMD(L+1)-FTAD)3714,3713,3713
FTAX=0.
GO TO 3750
FTAX=FTAD-AMD(L+1)
FTAD=AMD(L+1)
GO TO 3750
FTAX=FRA
IF(AMX(L+1)-FTAX)3719,3718,3718
FTAD=0.
GO TO 3750
FTAD=FTAX-AMX(L+1)
FTAX=AMX(L+1)
GO TO 3750
IF(-WS-WS1)3802,3802,3801
AMPY=-AMPY/WS*WS1
IF(-WSA-WS2)3200,3200,3803
TDM=-TDM/WSA*WS2
IF(TR)4010,3024,3024
WS1=AMX(K+1)
WS2=AMD(K+1)
IF(J-1)3999,4001,3999
IF(I-IMAX)4002,3024,4002
FB=V(K+1)
IF(CVIS)4004,4005,4005
IF(I-IMAX)4003,3024,4003
KB=K+1-IMAX
FB=(V(K+1)+V(KB))*.5
IF(FB)4006,4005,4005
WS=0.
WSA=0.
GO TO 4100
IF(DKE(K+1))4030,3024,4007
KB=K+1-IMAX
FB=FB*(AMX(K+1)+AMD(K+1))/DY(J)*DT
IF(DKE(KB))4014,4013,4011
KB=K+1
```

```
      GO TO 4011
 4011 FBAX=AMX(KB)/(AMX(KB)+AMD(KB))*FB
      FBAD=AMD(KB)/(AMX(KB)+AMD(KB))*FB
 4012 WS=WS+FBAX
      WSA=WSA+FBAD
      GO TO 4100
 4014 IF(DKE(KB)+1.0)4015,4019,4019
 4015 FBAX=FB
 4016 IF(AMX(K+1)+FB)4018,4017,4017
 4017 FBAD=0.
      GO TO 4012
 4018 FBAX=-AMX(K+1)
      FBAD=AMX(K+1)+FB
      GO TO 4012
 4019 FBAD=FB
 4020 IF(AMD(K+1)+FB)4022,4021,4021
 4021 FBAX=0.
      GO TO 4012
 4022 FBAD=-AMD(K+1)
      FBAX=AMD(K+1)+FB
      GO TO 4012
 4030 FB=FB*(AMX(K+1)+AMD(K+1))/DY(J)*DT
      IF(DKE(K+1)+1.0)4032,4031,4031
 4032 WS=WS+FB
      GO TO 4100
 4031 WSA=WSA+FB
 4100 IF(I+1-IMAX)4102,4101,4102
 4101 FRR=U(K+1)
      GO TO 4103
 4102 FRR=(U(K+1)+U(K+2))*.5
 4103 IF(FRR)4200,4200,4104
 4104 IF(DKE(K+1))4130,4200,4105
 4130 FRR=FRR*(AMX(K+1)+AMD(K+1))/(TAU(I)*DY(J))*2.0*PIDY
     1*X(I+1)*DT
 4140 IF(DKE(K+1)+1.0)4141,4142,4142
 4141 WS=WS-FRR
      GO TO 4200
 4142 WSA=WSA-FRR
      GO TO 4200
 4105 KR=K+2
 4106 FRR=FRR*(AMX(K+1)+AMD(K+1))/(TAU(I)*DY(J))*2.0*PIDY*
     1X(I+1)*DT
 4107 IF(DKE(KR))4110,4109,4108
 4109 KR=K+1
      GO TO 4108
 4108 FBAX=AMX(KR)/(AMX(KR)+AMD(KR))*FRR
      FBAD=AMD(KR)/(AMX(KR)+AMD(KR))*FRR
 4150 WS=WS-FBAX
      WSA=WSA-FBAD
      GO TO 4200
 4110 IF(DKE(KR)+1.0)4112,4111,4111
 4111 FBAD=FRR
 4116 IF(AMD(K+1)-FRR)4118,4117,4117
 4117 FBAX=0.
      GO TO 4150
 4118 FBAD=AMD(K+1)
      FBAX=FRR-AMD(K+1)
```

```
      GO TO 4150
 4112 FBAX=FRR
 4113 IF(AMX(K+1)-FRR)4115,4114,4114
 4114 FBAD=0.
      GO TO 4150
 4115 FBAX=AMX(K+1)
      FBAD=FRR-AMX(K+1)
      GO TO 4150
 4200 IF(VEL)4203,4203,4201
 4201 IF(FS)4202,4202,4300
 4202 FAB=V(K+1)
      GO TO 4206
 4203 IF(FS)4204,4204,4300
 4204 KA=K+1+IMAX
 4205 FAB=(V(KA)+V(K+1))*.5
 4206 IF(FAB)4300,4300,4207
 4207 FAB=FAB*(AMX(K+1)+AMD(K+1))/DY(J)*DT
 4208 IF(DKE(K+1))4209,4300,4212
 4212 KA=K+1+IMAX
      GO TO 4220
 4209 IF(DKE(K+1)+1.0)4210,4211,4211
 4210 WS=WS-FAB
      GO TO 4300
 4211 WSA=WSA-FAB
      GO TO 4300
 4220 IF(DKE(KA))4230,4221,4222
 4221 KA=K+1
      GO TO 4222
 4222 FBAX=AMX(KA)/(AMX(KA)+AMD(KA))*FAB
      FBAD=AMD(KA)/(AMX(KA)+AMD(KA))*FAB
 4250 WS=WS-FBAX
      WSA=WSA-FBAD
      GO TO 4300
 4230 IF(DKE(KA)+1.0)4224,4223,4223
 4224 FBAX=FAB
 4225 IF(AMX(K+1)-FAB)4227,4226,4226
 4226 FBAD=0.
      GO TO 4250
 4227 FBAX=AMX(K+1)
      FBAD=FAB-AMX(K+1)
      GO TO 4250
 4223 FBAD=FAB
 4228 IF(AMD(K+1)-FAB)4231,4229,4229
 4229 FBAX=0.
      GO TO 4250
 4231 FBAD=AMD(K+1)
      FBAX=FAB-AMD(K+1)
      GO TO 4250
 4300 IF(-WS-WS1)4302,4302,4301
 4301 AMMP=-AMMP/WS*WS1
 4302 IF(-WSA-WS2)3024,4303,4303
 4303 RDM=-RDM/WSA*WS2
 3024 CONTINUE
C
C     FINIS OF ELABORATE LOOK AHEAD.
C     CHECK POSSIBLE OPTIONS TO LIMIT THE
C     MAGNITUDE OF THE FLUXES
```

```
5500 IF(AMPY) 5504,5600,5501
5501 IF(VEL) 5502,5502,5600
5502 WS=TAU(I)*DY(J+1)
     IF(AMPY/WS - Z(144)) 5503,5503,5600
5503 AMPY=0.
     GO TO 5600
5504 WS=TAU(I)*DY(J)
     IF(-AMPY/WS - Z(144)) 5503,5503,5600
5600 IF(TDM) 5604,5700,5601
5601 IF (VEL) 5602,5602,5700
5602 WS=TAU(I)*DY(J+1)
     IF(TDM/WS - Z(143)) 5603,5603,5700
5603 TDM=0.
     GO TO 5700
5604 WS=TAU(I)*DY(J)
     IF(-TDM/WS - Z(143)) 5603,5603,5700
5700 IF(AMMP) 5704,5800,5701
5701 IF(FS)5702,5702,5800
5702 WS=TAU(I+1)*DY(J)
     IF(AMMP/WS-Z(144)) 5703,5703,5800
5703 AMMP=0.
     GO TO 5800
5704 WS=TAU(I)*DY(J)
     IF(-AMMP/WS-Z(144)) 5703,5703,5800
5800 IF(RDM) 5804,5900,5801
5801 IF(FS)5802,5802,5900
5802 WS=TAU(I)*DY(J)
     IF(RDM/WS-Z(143)) 5803,5803,5900
5803 RDM=0.
     GO TO 5900
5804 WS=TAU(I)*DY(J)
     IF(-RDM/WS - Z(143)) 5803,5803,5900
5900 CONTINUE
 900 IF(AMPY) 901,920,920
 901 IF(GAMC(J+1)) 903,902,902
 903 WS=AMX(L)+GAMC(J+1)
 904 IF(WS + AMPY) 905,920,920
 905 AMPY =-WS
     GO TO 920
 902 WS=AMX(L)
     GO TO 904
 920 IF(TDM) 921,930,930
 921 IF(DMASL(J+1)) 923,922,922
 923 WS=AMD(L)+DMASL(J+1)
 924 IF(WS+TDM) 925,930,930
 925 TDM=-WS
     GO TO 930
 922 WS=AMD(L)
     GO TO 924
 930 IF(AMMP) 931,940,940
 931 IF(AMX(K+1) + AMMP) 932,940,940
 932 AMMP=-AMX(K+1)
 940 IF(RDM) 941,954,954
 941 IF(AMD(K+1) + RDM) 942,954,954
 942 RDM=-AMD(K+1)
 954 CONTINUE
  74 JTAG=0
```
PH2 2260

```
  309 IF(AMPY+TDM)8834,8831,8833
 8833 IF(JMAX-J)9911,318,8835
 8835 KP=K+IMAX
 8836 IF(AMX(KP)+AMD(KP))9900,8837,318
C     RULES FOR TOP FREE SURFACE WITHIN THE GRID
 8837 IF((AMPY+TDM)/(TAU(I)*DY(J))-TOZONE)8838,318,318
 8838 AMPY=0.0
      TDM=0.
      GO TO 8831
 8834 IF(J-1)9911,325,8839
 8839 IF(AMX(K)+AMD(K))9900,8840,325
C     RULES FOR BOTTOM FREE SURFACE WITHIN THE GRID
 8840 IF((-AMPY-TDM)/(TAU(I)*DY(J+1))-TOZONE)8841,325,325
 8841 AMPY=0.0
      TDM=0.
      GO TO 8831
  318 DELM=GAMC(J)+AMMY-AMPY
      DELMD=DMASL(J)+BDM-TDM
  322 IF(VEL)9901,324,323
  323 WS=U(K)**2+V(K)**2
      ETH=ETH-AMPY*(AIX(K)+WS/2.0)
      ETH=ETH-TDM*(AID(K)+WS/2.)
C     A TRANSMITTIVE SURFACE AT TOP GRID BOUNDARY,
C     CHECK FOR SUFFICIENT MASS TO TRIGGER REZONE.
      IF((AMPY+TDM)/(TAU(I)*DY(J))-TOZONE)324,324,6900
 6900 REZ=1.0
C     CALCULATE THE MOMENTUM OF THESE TOP FLUXES
  324 AMUT=AMPY*U(K)
      AMVT=AMPY*V(K)
      TDXM=TDM*U(K)
      TDYM=TDM*V(K)
      GO TO 326
  325 CONTINUE
C     CALCULATE THE MOMENTUM OF THESE TOP FLUXES
 8831 AMUT=AMPY*U(L)
      AMVT=AMPY*V(L)
      TDXM=TDM*U(L)
      TDYM=TDM*V(L)
C     DELM = MASS AT LEFT + BOTTOM - TOP FOR X MATERIAL
      DELM=GAMC(J)-AMPY+AMMY
C     DELMD = SIMILAR FUNCTION FOR DOT MATERIAL
      DELMD=DMASL(J)+BDM-TDM
  326 IF(AMPY)327,328,328
  327 DELET=AIX(L)+(U(L)**2+V(L)**2)/2.0
      GO TO 333
  328 IF(AMMY)329,330,330
  329 DELET=DELEB
      GO TO 333
  330 IF(GAMC(J))331,332,332
  331 DELET=SIGC(J)
      GO TO 333
C     NOW WE HAVE SPECIFIC ENERGY CARRIED BY
C     THE X FLUX.
  332 DELET=AIX(K)+(U(K)**2+V(K)**2)/2.0
  333 IF(TDM)8810,8811,8811
 8810 TDTE=AID(L)+(U(L)**2+V(L)**2)/2.
      GO TO 8817
```

```
 8811 IF(BDM)8812,8813,8813
 8812 TDTE=BDTE
      GO TO 8817
 8813 IF(DMASL(J))8814,8815,8815
 8814 TDTE=DENRG(J)
      GO TO 8817
C     NOW WE HAVE SPECIFIC ENERGY CARRIED BY
C     THE DOT FLUX
 8815 TDTE=AID(K)+(U(K)**2+V(K)**2)/2.
C     SUM UP EACH COMPONENT OF MOMENTUM
C     FOR EACH MATERIAL, EXCEPT THE RIGHT FLUX
C     AND MOMENTA OF CELL IN QUESTION.
 8817 SIGMU=FLEFT(J)+AMMU-AMUT
      SIGMUD=DXML(J)+BDXM-TDXM
      SIGMV=YAMC(J)+AMMV-AMVT                                 PH2 3750
      SIGMVD=DYML(J)+BDYM-TDYM
C     SUM UP THE CHANGE IN ENERGY (BOTH X
C     AND .) FOR THE CELL IN QUESTION EXCEPT
C     FOR ENERGY AT THE RIGHT AND ENERGY OF THE
C     CELL IN QUESTION.
      DELEK=GAMC(J)*SIGC(J)+AMMY*DELEB-AMPY*DELET             PH2 3760
      DELED=DMASL(J)*DENRG(J)+BDM*BDTE
     1-TDM*TDTE
  509 IF(AMMP+RDM)8843,518,8844
 8844 IF(IMAX-I)9911,518,8845                                 PH2 3780
 8845 IF(AMX(K+1)+AMD(K+1))9900,8846,518
C     RULES FOR FREE SURFACE AT THE RIGHT WITHIN
C     THE GRID.
 8846 IF((AMMP+RDM)/(TAU(I)*DY(J))-TOZONE)8847,518,518
 8847 AMMP=0.0                                                PH2 3810
      RDM=0.
      GO TO 518                                               PH2 3820
 8843 IF(I-1)9911,512,8848                                    PH2 3830
 8848 IF(AMX(K)+AMD(K))9900,8849,512
C     RULES FOR FREE SURFACE AT THE LEFT WITHIN
C     THE GRID.
 8849 IF((-AMMP-RDM)/(TAU(I+1)*DY(J))-TOZONE)8850,512,512
 8850 AMMP=0.0                                                PH2 3860
      RDM=0.
      GO TO 518                                               PH2 3870
C     NOW DELM = CHANGE IN X MASS FOR CELL K
  512 DELM=DELM-AMMP+AMX(K)                                   PH2 3880
C     NOW DELMD = CHANGE IN . MASS FOR CELL K
      DELMD=DELMD-RDM+AMD(K)
  513 CONTINUE                                                PH2 3890
  514 CONTINUE                                                PH2 3900
C     CALCULATE THE MOMENTUM OF THE RIGHT FLUXES
 8828 AMUR=AMMP*U(K+1)                                        PH2 3910
      RDXM=RDM*U(K+1)
      AMVR=AMMP*V(K+1)                                        PH2 3920
      RDYM=RDM*V(K+1)
      GO TO 525                                               PH2 3930
C     NOW DELM = CHANGE IN X MASS FOR CELL K
  518 DELM=DELM-AMMP+AMX(K)                                   PH2 3940
C     NOW DELMD = CHANGE IN . MASS FOR CELL K
      DELMD=DELMD-RDM+AMD(K)
  521 CONTINUE                                                PH2 3950
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```
  522 IF(FS)9905,524,523                                          PH2 3960
  523 WS=U(K)**2+V(K)**2                                          PH2 3970
      ETH=ETH-AMMP*(AIX(K)+WS/2.0)                                PH2 3980
      ETH=ETH-RDM*(AID(K)+WS/2.0)
C     A TRANSMITTIVE SURFACE AT RIGHT GRID BOUNDARY,
C     CHECK FOR SUFFICIENT MASS TO TRIGGER REZONE.
      IF((AMMP+RDM)/(TAU(I)*DY(J))-TOZONE)524,524,6901
 6901 REZ=1.0                                                     PH2 4000
  524 AMUR=AMMP*U(K)                                              PH2 4010
      RDXM=RDM*U(K)
      AMVR=AMMP*V(K)                                              PH2 4020
      RDYM=RDM*V(K)
C     NOW SUM THE NET MOMENTA CHANGES
C     BY THESE FLUXES
C
  525 SIGMU=SIGMU-AMUR                                            PH2 4030
      SIGMUD=SIGMUD-RDXM
      SIGMV=SIGMV-AMVR                                            PH2 4040
      SIGMVD=SIGMVD-RDYM
  526 TIC=0.0                                                     PH2 4050
  527 IF(AMMP)528,529,529                                         PH2 4060
  528 DELER=AIX(K+1)+(U(K+1)**2+V(K+1)**2)/2.0                    PH2 4070
      GO TO 537                                                   PH2 4080
  529 IF(AMMY)530,531,531                                         PH2 4090
  530 DELER=DELEB                                                 PH2 4100
      GO TO 536                                                   PH2 4110
  531 IF(GAMC(J))532,533,533                                      PH2 4120
  532 DELER=SIGC(J)                                               PH2 4130
      GO TO 536                                                   PH2 4140
  533 IF(AMPY)535,535,534                                         PH2 4150
  534 DELER=DELET                                                 PH2 4160
      GO TO 536                                                   PH2 4170
C     NOW WE HAVE THE SPECIFIC ENERGY FOR FLUX
C     AT THE RIGHT FOR X MATERIAL
  535 DELER=AIX(K)+(U(K)**2+V(K)**2)/2.0                          PH2 4180
  536 TIC=1.0                                                     PH2 4190
C     NOW WE HAVE TOTAL CHANGE IN ENERGY BY
C     THE 4 FLUXES FOR X MATERIAL
  537 DELEK=DELEK-AMMP*DELER                                      PH2 4200
  999 IF(RDM)700,701,701
  700 RDTE=AID(K+1)+(U(K+1)**2+V(K+1)**2)/2.
      GO TO 710
  701 IF(BDM)702,703,703
  702 RDTE=BDTE
      GO TO 710
  703 IF(DMASL(J))704,705,705
  704 RDTE=DENRG(J)
      GO TO 710
  705 IF(TDM)706,706,707
  707 RDTE=TDTE
      GO TO 710
C     NOW, THE SPECIFIC ENERGY FOR THE FLUX
C     AT THE RIGHT FOR DOT MATERIAL.
  706 RDTE=(U(K)**2+V(K)**2)/2.+AID(K)
C     NOW WE HAVE TOTAL CHANGE IN ENERGY
C     BY THE 4 FLUXES FOR DOT MATERIAL.
  710 DELED=DELED-RDM*RDTE
```

```
  539 WS=(U(K)**2+V(K)**2)/2.0
      IF(DELM)998,712,712
  998 IF(AMX(K)*1.E-6+DELM)9906,997,997
  997 DELM=0.
  712 IF(DELMD)713,714,714
  713 IF(AMD(K)*1.E-6+DELMD)9906,715,715
  715 DELMD=0.
  714 CONTINUE
  540 ENK=AMX(K)*(WS+AIX(K))+DELEK
      DENK=AMD(K)*(WS+AID(K))+DELED
      WSA=DELM+DELMD
      IF(WSA)543,543,541
C
C     CONSERVE MOMENTUM TO CALCULATE THE
C     RADIAL VELOCITY COMPONENT
C
  541 U(K)=(SIGMU+SIGMUD+(AMX(K)+AMD(K))*U(K))/WSA
      IF(ABS(U(K)) -Z(146)) 9951,9951,601
 9951 ETH1=ETH1+(DELM+DELMD)/2.*(U(K)**2)
      U(K)=0.
C
C     CONSERVE MOMENTUM TO CALCULATE THE
C     AXIAL VELOCITY COMPONENT.
C
  601 V(K)=(SIGMV+SIGMVD+(AMX(K)+AMD(K))*V(K))/WSA
      IF(ABS(V(K))-Z(146)) 9952,9952,9953
 9952 ETH1=ETH1+(DELM+DELMD)/2.*(V(K)**2)
      V(K)=0.
C     CHECK FOR ADVANCING ACTIVE GRID COUNTER
C     IN THE RADIAL DIRECTION.
 9953 IF(I-I1)603,6604,6604
 6604 IF(U(K))6605,6606,6605
 6605 NRC=1
 6606 IF(V(K))6607,6608,6607
 6607 NRC=1
 6608 IF(AIX(K)+AID(K))6609,6610,6609
 6609 NRC=1
 6610 CONTINUE
  603 WS=U(K)**2+V(K)**2
  542 CONTINUE
      IF(DELM+DELMD)543,543,750
  750 IF(DELM)751,751,752
  751 AID(K)=DENK/DELMD-WS/2.
      DKE(K)=-1.
      GO TO 543
  752 IF(DELMD)753,753,754
  753 AIX(K)=ENK/DELM-WS/2.
      DKE(K)=-2.
      GO TO 543
  754 CONTINUE
C
C     THE NEW INTERNAL ENERGY IS THE TOTAL
C     LESS THE KINETIC
C
      DQ=ENK+DENK-.5*WS*(DELM+DELMD)
      WS= ENK +DENK
C
```

```
C     CALCULATE THE NEW SPECIFIC INTERNAL ENERGIES
C     FOR EACH MATERIAL
C
      AIX(K)=ENK/DELM/WS*DQ
      AID(K)=DENK/DELMD/WS*DQ
      DKE(K)=1.
  543 AMX(K)=DELM                                              PH2 4420
      AMD(K)=DELMD
      IF(AMX(K)+AMD(K))9900,2007,725
 2007 AIX(K)=0.
      AID(K)=0.
      DKE(K)=0.
      U(K)=0.
      V(K)=0.
      P(K)=0.
      GO TO 544
  725 IF(AMX(K))9900,716,717
  716 AIX(K)=0.
      DKE(K)=-1.
      GO TO 544
  717 IF(AMD(K))9900,718,719
  718 AID(K)=0.
      DKE(K)=-2.
      GO TO 544
  719 CONTINUE
C
C     SET THE LEFT QUANTITIES WITH THOSE FROM THE
C     RIGHT FOR THE NEXT COLUMN SWEEP.
C
  544 GAMC(J)=AMMP                                             PH2 4480
      FLEFT(J)=AMUR                                            PH2 4490
      YAMC(J)=AMVR                                             PH2 4500
      SIGC(J)=DELER                                            PH2 4510
      DMASL(J)=RDM
      DXML(J)=RDXM
      DYML(J)=RDYM
      DENRG(J)=RDTE
C
C     SET THE BOTTOM QUANTITIES WITH THOSE
C     FROM THE TOP FOR THE NEXT CELL ABOVE
C
  545 AMMY=AMPY                                                PH2 4520
      AMMU=AMUT                                                PH2 4530
      AMMV=AMVT                                                PH2 4540
      DELEB=DELET                                              PH2 4550
      BDM=TDM
      BDXM=TDXM
      BDYM=TDYM
      BDTE=TDTE
  546 K=K+IMAX                                                 PH2 4560
      LL=K-IMAX                                                PH2 4570
C     CHECK FOR ADVANCING THE ACTIVE GRID IN THE
C     AXIAL DIRECTION.
      IF(U(LL))6500,6600,6500                                  PH2 4580
 6500 NRT=1                                                    PH2 4590
 6600 IF(V(LL))6601,6602,6601                                  PH2 4600
 6601 NRT=1                                                    PH2 4610
```

```
 6602 IF(AIX(LL)+AID(LL))6611,547,6611
 6611 NRT=1
  547 CONTINUE
C     ADVANCE ACTIVE GRID COUNTERS
      I1=I1+NRC
      I2=I2+NRT
      IF(IMAX-I1)6700,6701,6702
 6700 I1=IMAX
 6701 CONTINUE
 6702 IF(JMAX-I2)6800,6801,6802
 6800 I2=JMAX
 6801 CONTINUE
 6802 GO TO 548
 9901 NK=300
      GO TO 9999
 9900 NK=302
      GO TO 9999
 9903 NK=305
      GO TO 9999
 9904 NK=506
      GO TO 9999
 9905 NK=500
      GO TO 9999
 9906 NK=998
C     AND STATEMENT NO. 713 ALSO
      GO TO 9999
 9911 NK=8833
      GO TO 9999
 9908 NK= 17
      GO TO 9999
 9909 NK= 22
      GO TO 9999
 9910 NK= 47
      GO TO 9999
 9907 NK=538
 9999 NR=4
      WRITE(6,9939)I,J,K,L,N,I1,I2,NK,NR
      WRITE(6,9938)AMPY,AMUT,AMVT,DELET,AMMP,AMUR,AMVR,DELER
      WRITE(6,9938)AMMY,AMMU,AMMV,DELEB,GAMC(J),FLEFT(J),YAMC(J),SIGC(J)
      WRITE(6,9938)TDM,TDXM,TDYM,TDTE,RDM,RDXM,RDYM,RDTE
      WRITE(6,9938)BDM,BDXM,BDYM,BDTE,DMASL(J),DXML(J),DYML(J),DENRG(J)
      WRITE(6,9939)NX,ND
      WRITE(6,9938)DELM,DELMD,SIGMU,SIGMUD,SIGMV,SIGMVD,DELEK,DELED
      WRITE(6,9938)AMX(K),AIX(K),U(K),V(K),AMD(K),AID(K),P(K)
      WRITE(6,9938)AMX(L),AIX(L),U(L),V(L),AMD(L),AID(L),P(L)
 9939 FORMAT(9I6)
 9938 FORMAT(1P8E12.5)
      CALL DUMP
  548 SUM=0.0
 2005 DO 2001 I=1,I1
      K=I+1
      DO 2013 J=1,I2
      WSA=0.
      WS=TAU(I)*DY(J)
      IF(AMX(K))5952,5952,5950
C     OPTION FOR REMOVING LOW DENSITY X MASS
 5950 IF(AMX(K)/WS-Z(107))5951,5951,5952
```

```
 5951 WSA=(U(K)**2+V(K)**2)/2.
      Z(100)=Z(100)+AMX(K)
      WSA=AMX(K)*(AIX(K)+WSA)
      SUM=SUM+WSA
      Z(101)=Z(101)-WSA
      AMX(K)=0.
      AIX(K)=0.
 5952 IF(AMD(K))5960,5960,5963
C     OPTION FOR REMOVING LOW DENSITY . MASS
 5963 IF(AMD(K)/WS-Z(108))5962,5962,5960
 5962 WSA=(U(K)**2+V(K)**2)/2.
      Z(100)=Z(100)+AMD(K)
      WSA=AMD(K)*(AID(K)+WSA)
      SUM=SUM+WSA
      Z(101)=Z(101)-WSA
      AMD(K)=0.
      AID(K)=0.
 5960 IF(AMD(K)+AMX(K))5961,5961,2008
 5961 U(K)=0.
      V(K)=0.
      P(K)=0.
      DKE(K)=0.
      GO TO 2013
C     OPTION FOR REMOVING SMALL (OR NEGATIVE)
C     INTERNAL ENERGIES FOR MATERIAL (X)
 2008 IF(AIX(K) -Z(145)) 2004,2011,2011                          PH2 5170
 2004 SUM=SUM+AIX(K)*AMX(K)                                       PH2 5180
      AIX(K)=0.0
C     OPTION FOR REMOVING SMALL (OR NEGATIVE)
C     INTERNAL ENERGIES FOR MATERIAL (DOT)
 2011 IF(AID(K)-Z(145))2012,2000,2000
 2012 SUM=SUM+AID(K)*AMD(K)
      AID(K)=0.
 2000 IF(AMX(K)+AMD(K))4400,4400,4401
 4401 IF(AMX(K))4402,4402,4403
 4402 DKE(K)=-1.
      GO TO 2013
 4403 IF(AMD(K))2009,2009,2010
 2009 DKE(K)=-2.
      GO TO 2013
 2010 DKE(K)=1.
      GO TO 2013
 4400 DKE(K)=0.
 2013 K=K+IMAX                                                    PH2 5200
 2001 CONTINUE
      ETH=ETH-SUM-ETH1                                            PH2 5220
      Z(104)=Z(104)+SUM
C     CHECK IF REZONE FLAG HAS BEEN SET BY PH2
 8000 IF(REZ)8001,8001,8002
C     CHECK IF YOU WANT TO CALL REZONE
 8002 IF(REZFCT)8004,8004,8003
 8004 REZ=0.
      GO TO 8001
 8003 CALL REZONE                                                 PH2 5260
 8001 RETURN
      END
C
```

```
C     ----------------------------------------------------------------
C
      SUBROUTINE ES
C
C
  200 IF(AMX(K))9901,201,202
C     DOT MATERIAL ONLY
  201 BEL=-1.
      WS3=1.
      WSA=1.
  210 WS1=AMD(K)
      WS2=AID(K)
      JJ=116
      DO 701 II=1,10
      PR(II)=Z(JJ)
      JJ=JJ+2
  701 CONTINUE
      GO TO 10
  202 IF(AMD(K))9901,203,204
C      X MATERIAL ONLY
  203 BEL=-1.
      WSA=1.
      WS3=-1.
  211 CONTINUE
      WS1=AMX(K)
      WS2=AIX(K)
C      HERE SET  Z BLOCK DATA FOR (X) MATERIAL TO PR BLOCK
      JJ=115
      DO 700 II=1,10
      PR(II)=Z(JJ)
      JJ=JJ+2
  700 CONTINUE
      GO TO 10
C      MIXED CELL
C      Z(115)=RHONOT FOR X
C      Z(116)=RHONOT FOR (.)
  204 EPSI=.5
      WSA=EPSI
      WS3=-1.
      BEL=1.
      NN=0
      GO TO 211
   10 CONTINUE
      RHOW=WS1/(TAU(I)*DY(J))
      RHOW=RHOW/WSA
      ETA=RHOW/PR(1)
      VOW=1.0/ETA
   11 P1=WS2*RHOW*PR(2)
   12 P2=WS2
      P3=ETA*ETA*PR(3)
   14 P4=PR(4)/(P2/P3+1.)*WS2*RHOW
   15 P5=PR(5)*(ETA-1.)
   16 IF(ETA-1.)50,100,100
   50 IF(VOW-PR(6))55,55,75
   55 IF(WS2-PR(7))100,100,75
   75 P7=PR(8)*(VOW-1.)
      IF(P7-88.)4002,4002,4003
```

```
4003 P7=88.0
4002 CONTINUE
     P8=EXP(P7)
     P9=1./P8
     P10=PR(9)*((VOW-1.)**2)
     IF(P10-88.)4000,4000,4001
4001 P10=88.
4000 CONTINUE
     P11=EXP(P10)
     P12=1./P11
     WSC=P1+(P4+P5*P9)*P12
     GO TO 120
 100 P6=PR(10)*((ETA-1.)**2)
     WSC=P1+P4+P5+P6
 120 CONTINUE
 119 IF(WSC)999,999,500
 999 WSC=0.
     WS6X=.5
 500 IF(BEL)501,502,502
C    CELL IS NOT MIXED
 501 P(K)=WSC
     GO TO 600
 502 IF(WS3)503,509,509
 503 WS3=1.
     WSA=1.-WSA
     P(K)=WSC
     EPSI=1.-WSA
     GO TO 210
C    N1 = MAX. NO. OF CYCLES FOR ITERATION
 509 IF(N1-NN)420,13,13
  13 NN=NN+1
     IF(P(K))510,510,511
 510 P(K)=0.
     GO TO 400
 511 WS1=ABS(P(K)-WSC)
     IF(WS1/ABS(P(K))-.05)420,420,410
 410 IF(P(K)-WSC)400,420,401
 420 P(K)=(P(K)+WSC)/2.
     DKE(K)=EPSI
     GO TO 600
C    FEF = EPSILON TO INCREASE OR DECREASE PARTIAL
C    VOLUMES FOR THE ITERATION
 401 EPSI=EPSI+FEF
     IF(EPSI-.99)710,710,711
 711 EPSI=.99
 710 WSA=EPSI
     WS3=-1.
     GO TO 211
 400 EPSI=EPSI-FEF
     IF(EPSI-.01)712,712,713
 712 EPSI=.01
 713 WSA=EPSI
     WS3=-1.
     GO TO 211
9901 NK=200
     NR=9999
     CALL DUMP
```

```
  600 WSGX=.5
      RETURN
      END
C
C     ----------------------------------------------------------------
C
      SUBROUTINE EDIT                                                   EDIT0050
C                                                                       EDIT1010
C                        E D I T                                        EDIT1130
  100 IF(SWITCH)102,104,102                                             EDIT1140
  102 CALL SSWTCH(4,K000FX)                                             EDIT1150
       GO TO(122,104),K000FX                                            EDIT1160
C                        FIRST CYCLE OF THE RUN (SENSE LIGHT 3 ON)      EDIT1170
  104 CALL SLITET(3,K000FX)                                             EDIT1180
       GO TO(106,108),K000FX                                            EDIT1190
  106 CALL SLITE (3)                                                    EDIT1200
      GO TO 126                                                         EDIT1210
  108 IF(CYCLE-CSTOP)110,122,122                                        EDIT1220
  110 IF(REZ)9901,112,124                                               EDIT1230
  112 IF(AMOD(CYCLE,DUMPT7))114,124,114                                 EDIT1240
  114 IF(AMOD(CYCLE,PRINTL))116,126,116                                 EDIT1250
  116 IF(SWITCH)118,120,118                                             EDIT1260
  118 CALL SSWTCH(5,K000FX)                                             EDIT1270
       GO TO(128,120),K000FX                                            EDIT1280
  120 IF(AMOD(CYCLE,PRINTS))140,128,140                                 EDIT1290
C                        NORMAL OR FORCED STOP ON THIS CYCLE            EDIT1300
  122 CALL SLITE (1)                                                    EDIT1310
C                        EXECUTE WTAPE - DUMP VARIABLES ONTO TAPE 7     EDIT1320
  124 GO TO 1                                                           EDIT1330
C                        SET SENSE LIGHT TO INDICATE TAKING OF LONG PRINT  EDIT1340
  126 CALL SLITE (4)                                                    EDIT1350
C                        EXECUTE SP - WRITE THE SHORT PRINT INFORMATION EDIT1360
  128 GO TO 6000                                                        EDIT1370
C                        EXECUTE PLOT - PLOT THE FILLED CELL DISTRIBUTION  EDIT1380
  130 GO TO 1000                                                        EDIT1410
  132 CALL SLITET(4,K000FX)                                             EDIT1420
       GO TO(134,136),K000FX                                            EDIT1430
C                        EXECUTE LP - WRITE THE LONG PRINT INFORMATION  EDIT1440
  134 GO TO 5000                                                        EDIT1450
C                        TEST FOR AN ENERGY CHECK VIOLATION             EDIT1460
  136 IF(ABS(ECK)-DMIN)140,140,9905                                     EDIT1470
  140 CALL SLITET(1,K000FX)                                             EDIT1480
       GO TO(142,144),K000FX                                            EDIT1490
  142 REWIND N7

      CALL SLITE (1)                                                    EDIT1510
  144 GO TO 10000                                                       EDIT1520
C                                                                       EDIT1530
C                                                                       EDIT1540
C**** SUBROUTINE WTAPE ***********************************************EDIT1550
    1 IF(DUMPT7)30,3,3                                                  EDIT1580
    3 BACKSPACE N7
      WS=555.0                                                          EDIT1620
      WRITE(N7)WS,CYCLE,N3
      WRITE(N7)(Z(L),L=1,MZ)
    6 WRITE(N7)(U(I),V(I),AMD(I),AMX(I),AID(I),AIX(I),
     1P(I),DKE(I),I=1,KMAXA)
```

```
    7 WRITE(N7)(X(K),TAU(K),K=1,IMAX)
      WRITE(N7)(Y(K),K=1,JMAX)
      WS=666.0                                                          EDIT1780
      WRITE(N7)WS,WS,WS
      WRITE (6,8120)NC                                                  EDIT1800
   30 GO TO 126                                                         EDIT1810
C**** END OF  WTAPE SUBROUTINE ****************************************EDIT1820
C                                                                       EDIT1830
C                                                                       EDIT1840
C**** SUBROUTINE S P **************************************************EDIT1850
C                   SIZE OF TABLE                                       EDIT1860
 6000 NK=12                                                             EDIT1870
      TAB(1)=0.02                                                       EDIT1880
      TAB(2)=0.04                                                       EDIT1890
      TAB(3)=0.06                                                       EDIT1900
      TAB(4)=0.08                                                       EDIT1910
      TAB(5)=0.10                                                       EDIT1920
      TAB(6)=0.15                                                       EDIT1930
      TAB(7)=0.20                                                       EDIT1940
      TAB(8)=0.25                                                       EDIT1950
      TAB(9)=0.30                                                       EDIT1960
      TAB(10)=0.4                                                       EDIT1970
      TAB(11)=0.5                                                       EDIT1980
      TAB(12)=1.0                                                       EDIT1990
 6010 DO 6012 I=1,18                                                    EDIT2000
 6012 PR(I)=0.0                                                         EDIT2010
      NK1=NK+2                                                          EDIT2020
      DO 6014 I=1,NK1                                                   EDIT2030
C     TEMPORARY USE PARTICLE STORAGE FOR EDITING
      AM(I)=0.
      XL(I)=0.
      YL(I)=0.
      AMK(I)=0.0                                                        EDIT2040
      PK(I)=0.0                                                         EDIT2050
 6014 QK(I)=0.0                                                         EDIT2060
      DO 6028 K=2,KMAX                                                  EDIT2070
      WSB=(U(K)**2+V(K)**2)/2.0                                         EDIT2080
 6015 IF(AMD(K))9917,6019,6017                                          EDIT2090
 6017 PR(1)=AMD(K)*AID(K)+PR(1)
      PR(2)=AMD(K)*WSB+PR(2)
 6018 PR(4)=AMD(K)+PR(4)                                                EDIT2120
 6019 IF(AMX(K)+AMD(K))9917,6028,6020                                   EDIT2130
 6020 I=NK1                                                             EDIT2140
      IF(V(K))6026,6026,6022                                            EDIT2150
 6022 WSA=ABS(U(K))/V(K)                                                EDIT2160
      DO 6024 I=1,NK                                                    EDIT2170
      IF(TAB(I)-WSA)6024,6026,6026                                      EDIT2180
 6024 CONTINUE                                                          EDIT2190
      I=NK+1                                                            EDIT2200
 6026 WS=AMX(K)                                                         EDIT2210
 6027 AMK(I)=AMK(I)+AMX(K)+AMD(K)                                       EDIT2220
      XL(I)=XL(I)+U(K)*AMD(K)
      YL(I)=YL(I)+V(K)*AMD(K)
      PK(I)=PK(I)+U(K)*AMX(K)                                           EDIT2230
      QK(I)=QK(I)+V(K)*AMX(K)                                           EDIT2240
      PR(5)=PR(5)+AIX(K)*AMX(K)                                         EDIT2250
      PR(6)=PR(6)+WSB*AMX(K)                                            EDIT2260
```

```
      PR(8)=PR(8)+AMX(K)                                                EDIT2270
 6028 CONTINUE                                                          EDIT2280
      PR(3)=PR(1)+PR(2)                                                 EDIT2290
      PR(7)=PR(5)+PR(6)                                                 EDIT2300
      XNRG=PR(7)                                                        EDIT2310
      PR(9)=PR(1)+PR(5)                                                 EDIT2320
      PR(10)=PR(2)+PR(6)                                                EDIT2330
      PR(11)=PR(3)+PR(7)                                                EDIT2340
      PR(12)=PR(4)+PR(8)                                                EDIT2350
      IF(ETH)7002,7002,7003
 7002 WSA=0.
      GO TO 7000
 7003 CONTINUE
      WSA=(ETH-PR(11))/ETH                                              EDIT2360
      IF(NPC)7000,7000,7001
 7000 NPC=1
 7001 PR(18)=(WSA-DNN)/FLOAT(NPC)
      ECK=PR(18)                                                        EDIT2380
      DNN=WSA                                                           EDIT2390
      NPC=0                                                             EDIT2400
C     *** FOR PELLET PROBLEMS ONLY ****                                 EDIT2410
      SUMD=0.
      SUMX=0.
      DO 800 I=1,13                                                     EDIT2430
      SUMX=SUMX+QK(I)
      SUMD=SUMD+YL(I)
  800 CONTINUE                                                          EDIT2450
C     RADET=POSITIVE AXIAL MOMENTUM OF X
C     VABOVE=POSITIVE AXIAL MOMENTUM OF.
      RADET=SUMX
      VABOVE=SUMD
  801 SUM=0.0                                                           EDIT2470
      SUMD=0.
      DO 820 K=2,KMAX
      IF(AMX(K))810,810,802                                             EDIT2490
  802 IF(U(K))810,810,803                                               EDIT2500
  803 SUM=SUM+AMX(K)*U(K)                                               EDIT2510
  810 IF(AMD(K))820,820,821
  821 IF(U(K))820,820,823
  823 SUMD=SUMD+AMD(K)*U(K)
  820 CONTINUE
      RADER=SUM                                                         EDIT2530
      VBLO=SUMD
      PR(19)=0.0                                                        EDIT2540
      DO 6029 I=1,NK                                                    EDIT2550
 6029 PR(I+19)=PR(I+18)+AMK(I)                                          EDIT2560
      PR(NK+20)=0.0                                                     EDIT2570
      PR(NK+21)=0.0                                                     EDIT2580
      JJ=Z(147)
      SUMX=0.
      SUMD=0.
      DO 811 I=1,IMAX
      K=I+1
      DO 813 J=1,JJ
      IF(AMX(K))816,816,814
  814 IF(U(K))816,816,817
  817 SUMX=SUMX+U(K)*AMX(K)
```

```
  816 IF(AMD(K))813,813,818
  818 IF(U(K))813,813,819
  819 SUMD=SUMD+U(K)*AMD(K)
  813 K=K+IMAX
  811 CONTINUE
      PBLO=SUMX
      PABOVE=SUMD
      WRITE (6,8116)PROB,NC,T,DTNA,TRAD,DTRAD,NR,N1,N2,N3,N4          EDIT2590
      WRITE (6,8117)(PR(I),I=1,8)                                      EDIT2600
      WRITE (6,8118)(PR(I),I=9,12)                                     EDIT2610
      WRITE (6,8119)RADEB,RADER,RADET,UVMAX,ETH,ECK                    EDIT2620
      WRITE(6,8203)RADET,VABOVE,RADER,VBLO,PBLO,PABOVE
      WRITE (6,9040)N10,N11                                            EDIT2630
      WRITE (6,8124)(I,AMK(I),PR(I+19),PK(I),QK(I),I=1,NK1)            EDIT2640
 6090 GO TO 130                                                        EDIT2650
C**** END OF   S P  SUBROUTINE *******************************************EDIT2660
C                                                                      EDIT2670
C                                                                      EDIT2680
C**** SUBROUTINE PLOT * *************************************************EDIT2690
 1000 GO TO 1030                                                       EDIT2700
 1030 WRITE (6,8116)PROB,NC,T,DTNA,TRAD,DTRAD,NR,N1,N2,N3,N4          EDIT2710
      JMAX=JMAX                                                        EDIT2720
      WRITE (6,8307)DX(1),DY(1),XMAX,Y1,Y2,Y(JMAX)
      M=1                                                              EDIT2740
      IF(JMAX-52)1034,1036,1036                                        EDIT2750
 1034 M=IABS(51-JMAX)/2                                                EDIT2760
 1036 DO 1040 I=1,M                                                    EDIT2770
      WRITE (6,8308)                                                   EDIT2780
 1040 CONTINUE                                                         EDIT2790
 1044 J=I2
 1100 K=(J-1)*IMAX+1                                                   EDIT2810
 1105 DO 1180 I=1,I1
      K=K+1                                                            EDIT2830
 1126 PR(I)=PLOT(1)
C        TEST FOR DOT PARTICLE                                         EDIT2860
 1148 IF(AMD(K))9917,1150,1152                                         EDIT2870
C        TEST FOR X PARTICLE                                           EDIT2880
 1150 IF(AMX(K))9917,1166,1160                                         EDIT2890
C        TEST FOR MIXED CELL                                           EDIT2900
 1152 IF(AMX(K))9917,1162,1164                                         EDIT2910
C        X PARTICLE ONLY                                               EDIT2920
 1160 PR(I)=PLOT(2)
      GO TO 1180                                                       EDIT2950
C        DOT PARTICLE ONLY                                             EDIT2960
 1162 PR(I)=PLOT(3)
      GO TO 1180                                                       EDIT2990
C        MIXED CELL                                                    EDIT3000
 1164 PR(I)=PLOT(4)
      GO TO 1180                                                       EDIT3030
 1166 PR(I)=PLOT(1)
 1180 CONTINUE                                                         EDIT3060
 1200 IF(MOD(J,5))1210,1204,1210                                       EDIT3070
 1204 IF(DY(J)-DY(J-1))1206,1208,1206                                  EDIT3080
 1206 WRITE(6,8211)DY(J),J,(PR(I),I=1,I1)
      GO TO 1224                                                       EDIT3100
 1208 WRITE(6,8201)J,(PR(I),I=1,I1)
      GO TO 1224                                                       EDIT3120
```

```
 1210 IF(DY(J)-DY(J-1))1212,1214,1212                             EDIT3130
 1212 WRITE(6,8222)DY(J),(PR(I),I=1,I1)
      GO TO 1224                                                  EDIT3150
 1214 WRITE(6,8202)(PR(I),I=1,I1)
 1224 J=J-1                                                       EDIT3170
 1226 IF(J)1230,1230,1100                                         EDIT3180
 1230 PR(1)=PLOT(5)
      WRITE(6,8201)J,(PR(1),I=1,I1)
      WRITE (6,8302)(I,I=0,IMAX,5)                                EDIT3220
 1240 GO TO 132                                                   EDIT3290
C**** END OF  PLOT  SUBROUTINE ****************************************EDIT3300
C                                                                 EDIT3310
C                                                                 EDIT3320
C**** SUBROUTINE L P **************************************************EDIT3330
 5000 WRITE (6,8116)PROB,NC,T,DTNA,TRAD,DTRAD,NR,N1,N2,N3,N4      EDIT3340
 5004 DO 5050 I=1,I1
      CALL SLITE (4)                                              EDIT3360
      J=I2+1
      K=I2*IMAX+I+1
      DO 5046 L=1,I2
      J=J-1                                                       EDIT3400
      K=K-IMAX                                                    EDIT3410
 5012 IF(AMX(K)+AMD(K)) 917,5046,5014                             EDIT3420
 5014 CALL SLITET(4,KOOFX)                                        EDIT3430
      GO TO(5016,5019), OOOFX
 5016 WRITE (6,8135)I,X(I),DX(I)                                  EDIT3450
 5019 IF(AMX(K))5030,50 0,5031
 5030 WSB=AMD(K)/(TAU(I)*DY(J))
      WSB=WSB/Z(116)
      WSA=0.
      GO TO 5034
 5031 IF(AMD(K))5032,50 2,5033
 5032 WSA=AMX(K)/(TAU(I)*DY(J))
      WSA=WSA/Z(115)
      WSB=0.
      GO TO 5034
 5033 WSA=(AMX(K)+AMD(K))/(TAU(I)*DY(J))
      WSB=-.11111
 5034 WSC=P(K)*1.E+4
C     FIRST COLUMN J
C     SECOND COLUMN RADIAL VELOCITY CM./SH.
C     THIRD COLUMN AXIAL VELOCITY CM./SH.
C     FOURTH COLUMN PRESSURE IN MEGABARS
C     FIFTH COLUMN DKE(STATUS OF MIXED CELL)
C     SIXTH COLUMN MASS (OF X MATERIAL) IN GRAMS.
C     SEVENTH COLUMN SPECIFIC INTERNAL ENERGY FOR (X) IN JERKS/GR
C     EIGHT COLUMN MASS (OF . MATERIAL) IN GRAMS.
C     NINTH COLUMN SPECIFIC INTERNAL ENERGY FOR (.) IN JERKS/GR.
C     TENTH COLUMN DENSITY IN G/CC.
C     ELEVENTH COLUMN WSB
C     TWELFTH COLUMN Y (J) TOP COORDINATE OF CELL IN CM.
 5018 WRITE (6,8108)J,U(K),V(K),WSC,THETA(K),AMX(K),AIX(K),
     1AMD(K),AID(K),WSA,WSB,Y(J)
 5046 CONTINUE                                                    EDIT3480
 5050 CONTINUE                                                    EDIT3490
      GO TO 136                                                   EDIT3500
C *** END OF   L P  SUBROUTINE ****************************************EDIT3510
```

```
C                                                                       EDIT3520
C                                                                       EDIT3530
C                 ERROR                                                 EDIT3540
 9901 NK=110                                                            EDIT3550
      GO TO 9999                                                        EDIT3560
C                 ENERGY CHECK                                          EDIT3570
 9905 NK=136                                                            EDIT3580
      GO TO 9999                                                        EDIT3590
C                 NEGATIVE MASS                                         EDIT3600
 9917 NK=6015                                                           EDIT3610
      GO TO 9999                                                        EDIT3620
 9920 NK=904                                                            EDIT3630
      GO TO 9999                                                        EDIT3640
 9921 NK=912                                                            EDIT3650
      GO TO 9999                                                        EDIT3660
 9922 NK=918                                                            EDIT3670
      GO TO 9999                                                        EDIT3680
 9923 NK=922                                                            EDIT3690
      GO TO 9999                                                        EDIT3700
 9924 NK=926                                                            EDIT3710
 9999 NR=6                                                              EDIT3720
      CALL DUMP                                                         EDIT3740
10000 RETURN                                                            EDIT3750
C                                                                       EDIT3760
C                 FORMATS                                               EDIT3770
 8108 FORMAT(I3,1X,1P11E10.3)
 81160FORMAT(8H1PROBLEM5X,5HCYCLE9X,4HTIME13X,2HDT13X,4HTRAD11X,5HDTRAD1EDIT3790
     12X,2HNR6X,2HN14X,2HN24X,2HN34X,2HN4/(F7.1,I11,2X,1P4E16.7,I10,2X,4EDIT3800
     2I6))                                                              EDIT3810
 81170FORMAT(1H0//17X2HAI16X,2HAK14X,5HAI+AK15X,2HAM/4H DOT3X,1P4E18.7/3EDIT3820
     1H  X4X,4E18.7)                                                    EDIT3830
 81180FORMAT(12X,13H-------------5X,13H-------------5X,13H-------------5EDIT3840
     1X,13H-------------/7H TOTALS1P4E18.7)                             EDIT3850
 81190FORMAT(2H0 //16X,5HRADEB13X,5HRADER13X,5HRADET12X,7HMAX VEL13X,3HTEDIT3860
     1HE12X,9HREL ERROR/7X,1P6E18.7////)                                EDIT3870
 8120 FORMAT(1H0//21H TAPE 7 DUMP ON CYCLEI5////)                       EDIT3880
 81240FORMAT(3H  K12X,5HAM(K)11X,9HSUM AM(K)11X,4HP(K)13X,4HQ(K)/(I3,4X,EDIT3890
     11P4E18.7))                                                        EDIT3900
 8131 FORMAT(1H ///11H DY(J) J=1,I2//(10F12.3))                         EDIT3910
 8133 FORMAT(1H ///11H  Y(J) J=0,I2//(10F12.3))                         EDIT3920
 81350FORMAT(1H ///4H I =I3,6X,6HX(I) =F12.3,6X,7HDX(I) =F12.3//3H  J8X,EDIT3930
     11HU9X,1HV9X,3HF/A7X,3HDIE7X,3HAMX7X,3HAIX7X,3HAMD7X,3HAID7X,4HETAX
     2X6X,4HETAD6X,1HZ/)
 8201 FORMAT(I10,2H I54A2)                                              EDIT3950
 8202 FORMAT(10X,2H I54A2)                                              EDIT3960
 8203 FORMAT(3X,1P6E18.7)
 8211 FORMAT(F7.1,I3,2H I54A2)                                          EDIT3970
 8222 FORMAT(F7.1,3X,2H I54A2)                                          EDIT3980
 8302 FORMAT(I12,10I10)                                                 EDIT3990
 83070FORMAT(5H X1 =1PE12.6,3X,4HX2 =E12.6,3X,6HXMAX =E12.6,6X,4HY1 =E12EDIT4000
     1.6,3X,4HY2 =E12.6,3X,6HYMAX =E12.6)                               EDIT4010
 8308 FORMAT(1H /)                                                      EDIT4020
 9040 FORMAT(1H / 6I6)                                                  EDIT4030
      END                                                               EDIT4040
C
C     ---------------------------------------------------------------
C
```

```
      SUBROUTINE REZONE                                               REZO0010
C
C     NOTE, THIS VERSION ASSUMES THAT WE ARE
C     ADDING (.) MATERIAL
C
C
C     ********** A 2 MATERIAL OIL CODE **************************
C     A 2 MATERIAL REZONE SUBROUTINE
C     CONSERVE MOMENTUM AND TOTAL ENERGY, INCREASE
C     ALL LINEAR DIMENSIONS BY 2. (THUS 4 CELLS
C     IN THE OLD GRID ARE COMBINED INTO 1 FOR
C     THE NEW GRID.)
      NIMAX=IMAX/2                                                    REZO0990
      NJMAX=JMAX/2                                                    REZO1000
      DO 10 J=1,NJMAX                                                 REZO1010
      K=(J-1)*NIMAX+2                                                 REZO1020
      L=(J-1)*2*IMAX+2                                                REZO1030
      DO 11 I=1,NIMAX                                                 REZO1040
      M=L+IMAX                                                        REZO1050
   12 WSA=AMX(L)+AMX(M)+AMX(L+1)+AMX(M+1)                             REZO1060
      WSAD=AMD(L)+AMD(M)+AMD(L+1)+AMD(M+1)
      IF(WSA+WSAD)100,100,101
  100 AMX(K)=0.
      AIX(K)=0.
      AMD(K)=0.
      AID(K)=0.
      U(K)=0.
      V(K)=0.
      GO TO 9901
  101 CONTINUE
 8900 CONTINUE
      WSB=(AMX(L)+AMD(L))*(U(L)**2+V(L)**2)
      WSB=WSB+(AMX(M)+AMD(M))*(U(M)**2+V(M)**2)
      WSB=WSB+(AMX(L+1)+AMD(L+1))*(U(L+1)**2+V(L+1)**2)
      WSB=WSB+(AMX(M+1)+AMD(M+1))*(U(M+1)**2+V(M+1)**2)
      U(K)=U(L)*(AMX(L)+AMD(L))+U(M)*(AMX(M)+AMD(M))
     1+U(L+1)*(AMX(L+1)+AMD(L+1))+U(M+1)*(AMX(M+1)+AMD(M+1))
      U(K)=U(K)/(WSA+WSAD)
      V(K)=V(L)*(AMX(L)+AMD(L))+V(M)*(AMX(M)+AMD(M))
     1+V(L+1)*(AMX(L+1)+AMD(L+1))+V(M+1)*(AMX(M+1)+AMD(M+1))
      V(K)=V(K)/(WSA+WSAD)
      AIX(K)=AIX(L)*AMX(L)+AIX(M)*AMX(M)+AIX(L+1)*                    REZO1140
     1AMX(L+1)+AMX(M+1)*AIX(M+1)                                      REZO1150
      AMX(K)=WSA                                                      REZO1160
      AID(K) = AID(L)*AMD(L)+AID(M)*AMD(M) +
     1AID(L+1) *AMD(L+1) + AID(M+1)*AMD(M+1)
      AMD(K)=WSAD
      WS=U(K)**2+V(K)**2                                              REZO1170
      E=AIX(K) + AID(K)+ WSB/2.0
      IF(AMD(K)+AMX(K)) 9901,9901,500
  500 IF (AMD(K)) 501,501,502
C     X  ONLY
  501 AIX(K) = E/AMX(K) - .5*WS
      DKE(K)=-2.
      AID(K) = 0.
      GO TO 9901
  502 IF(AMX(K)) 503,503,504
```

```
C      DOT ONLY
  503 AID(K) = E/AMD(K) - .5* WS
      DKE(K)=-1.
      AIX(K) =0.
      GO TO 9901
C      MIXED CELL
  504 DQ=E-(AMX(K)+AMD(K))*WS/2.
      WSE=AIX(K)+AID(K)
      AIX(K)=AIX(K)/AMX(K)*DQ/WSE
      AID(K)=AID(K)/AMD(K)*DQ/WSE
      DKE(K)=1.
 9901 IF(K-2)14,14,13
C      SET CELL QUANTITIES OF OLD GRID TO ZERO.
   13 AMX(L)=0.0
      AMD(L)=0.
      U(L)=0.0
      V(L)=0.0
      AIX(L)=0.0
      AID(L)=0.
      P(L)=0.0
      DKE(L)=0.
      AMX(M)=0.0
      AMD(M)=0.
      U(M)=0.0
      V(M)=0.0
      AIX(M)=0.0
      AID(M)=0.
      P(M)=0.0
      DKE(M)=0.
      AMX(L+1)=0.0
      AMD(L+1)=0.
      U(L+1)=0.0
      V(L+1)=0.0
      AIX(L+1)=0.0
      AID(L+1)=0.
      P(L+1)=0.0
      DKE(L+1)=0.
      AMX(M+1)=0.0
      AMD(M+1)=0.
      U(M+1)=0.0
      V(M+1)=0.0
      AIX(M+1)=0.0
      AID(M+1)=0.
      P(M+1)=0.0
      DKE(M+1)=0.
   14 K=K+1
      L=L+2
   11 CONTINUE
   10 CONTINUE
C      CALCULATE NEW DY AND Y (JMAX OF THEM).
      I=0
      DO 200 J=1,JMAX,2
      I=I+1
      DY(I)=DY(J)+DY(J+1)
  200 CONTINUE
      II=NJMAX+1
      DO 201 J=II,JMAX
```

```
      DY(J)=DY(I)
  201 CONTINUE
      WS=0.
      DO 202 J=1,JMAX
      Y(J)=DY(J)+WS
      WS=Y(J)
  202 CONTINUE
C     CALCULATE THE NEW DX,S AND TAU,S
      I=0
      DO 203 J=1,IMAX,2
      I=I+1
      DX(I)=DX(J)+DX(J+1)
  203 CONTINUE
      II=NIMAX+1
      DO 204 J=II,IMAX
      DX(J)=DX(I)
  204 CONTINUE
      WS=0.
      WSA=0.
      DO 205 I=1,IMAX
      X(I)=DX(I)+WS
      WS=X(I)
      WSB=X(I)**2
      TAU(I)=PIDY*(WSB-WSA)
      WSA=WSB
  205 CONTINUE
      IMAX=NIMAX
      JMAX=NJMAX
C     PREPARE NOW TO SHUFFLE THE K ARRAYS SUCH
C     AS TO PRESERVE K=(J-1)*IMAX+I+1.
      DO 20 N=1,JMAX
      J=JMAX+1-N
      K=(J-1)*IMAX+1+IMAX
      L=(J-1)*(IMAX+IMAX)+1+IMAX
      DO 21 I=1,IMAX
 1000 AMX(L)=AMX(K)
      DKE(L)=DKE(K)
      AMD(L)=AMD(K)
      AIX(L)=AIX(K)
      AID(L)=AID(K)
      U(L)=U(K)
      V(L)=V(K)
      P(L)=P(K)
      IF(J-1)1002,1002,1001
 1001 AMX(K)=0.0
      AMD(K)=0.
      AIX(K)=0.0
      AID(K)=0.
      DKE(K)=0.
      V(K)=0.0
      U(K)=0.0
      P(K)=0.0
 1002 K=K-1
      L=L-1
   21 CONTINUE
   20 CONTINUE
      IMAX=NIMAX*2
```

```
      JMAX=NJMAX*2                                                      RE201850
      II=NIMAX+1
      JJ=NJMAX+1
C     ADD ON NEW MASS WITH DENSITY=Z(111) IN TARGET
      DO 50 I=1,NIMAX
      K=(JJ-1)*IMAX+I+1
      DO 60 J=JJ,JMAX
      AMD(K)=Z(111)*TAU(I)*DY(J)
   60 K=K+IMAX
   50 CONTINUE
      JJ=(Z(147)/2.+.2)
      JJ=JJ+1
      DO 61 I=II,IMAX
      K=I+1+(JJ-1)*IMAX
      DO 62 J=JJ,JMAX
      AMD(K)=Z(111)*TAU(I)*DY(J)
   62 K=K+IMAX
   61 CONTINUE
C     RESET ACTIVE GRID MARKERS.
      JJ=JJ-1
      Z(147)=JJ
      I1=I1/2+2
      I2=I2/2+2
      WS=T+DTNA
      NK=NC+1
C     EDIT THE NEW GRID.
      WRITE (6,8004)WS,NK,DX(1)
      WRITE (6,8007)IMAX,(X(I),I=0,IMAX)
      WRITE (6,8008)JMAX,(Y(J),J=0,JMAX)
      WRITE (6,8009)IMAX,(DX(I),I=1,IMAX)
      WRITE (6,8010)JMAX,(DY(J),J=1,JMAX)
      WRITE (6,8011)IMAX,(TAU(I),I=1,IMAX)
      KMAX=IMAX*JMAX+1
      IMAXA=IMAX+1
      JMAXA=JMAX+1
      KMAXA=KMAX+1
      RETURN
 8004 FORMAT(1H ////22H PROBLEM REZONED AT T=1PE12.6,6X,5HCYCLEI4,5X,3HDRE202190
     1X=E12.6////)
 8007 FORMAT(1H /10H X(I) I=0,I2/(5F16.6))
 8008 FORMAT(1H /10H Y(J) J=0,I2/(5F16.6))                              RE
 8009 FORMAT(1H /11H DX(I) I=1,I2/(5F16.6))
 8010 FORMAT(1H /11H DY(J) J=1,I2/(5F16.6))
 8011 FORMAT(1H /15H AREA(I) I=1,I2/(F16.6,4F18.6))
      END
C        --------------------------------------------------
C          ------------------------------------------------------------
```